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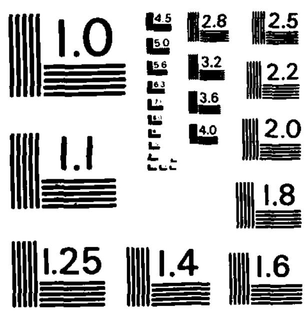

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RESEARCH AND DEVELOPMENT TECHNICAL REPORT

CECOM-DRSEL-TR-78-2922F

ULTRA LOW LOSS OPTICAL FIBER CABLE ASSEMBLIES

Volume 2

C. Hand
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7 June 1983

Final Report for Period December 1978 - December 1982

Approved for public release; distribution unlimited.

Prepared for
CENTER FOR COMMUNICATION SYSTEMS
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fiber optics; optical fibers; optical multifiber cable; ruggedized cable; fiber optic cable assemblies; fiber optic hermaphroditic connectors; fiber attenuation; fiber dispersion; test data on fibers; jeweled ferrule connectors; adjustable three-sphere connectors

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This final report describes the development of tactical fiber optic cable assemblies. The effort was to develop a tactically deployable cable capable of a transmission rate of 20 Mb/s over 8 km repeaterless lengths. The optical performance required to meet the requirements is a dispersion of less than 2 ns/km and an attenuation of less than 5 dB/km at 0.85 μm combined with connector interface losses of less than 1 dB (1.5 dB at bulkhead receptacle). Experimental results of fiber, cable, and cable assembly testing are reported.

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APPENDIX A

CONNECTOR PLUG

AND

BULKHEAD RECEPTABLE

DESIGN PLAN

ULTRA LOW LOSS OPTICAL FIBER

CABLE ASSEMBLIES

HERMAPHRODITIC CONNECTOR PLUG

AND BULKHEAD RECEPTACLE

DESIGN PLAN

CLIN 0007/A003(b)

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Date: May 30, 1980
Doc Id No: 80-22-07

PREFACE

This design plan describes the hermaphroditic connector plug and bulkhead receptacle that is being developed for the Center for Communications Systems, Multichannel Transmission Division, CORADCOM, by ITT Electro-Optical Products Division under contract DAAB07-78-C-2922.

This plan describes the recommended design for the development of a suitable jewel ferrule connector for terminating a ruggedized six-channel fiber optic cable for tactical field use.

The design and development effort described herein was subcontracted to ITT Cannon Electric Division under ITT EOPD Interworks Agreement A10208.

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D E S I G N P L A N

CONNECTOR PLUG

HERMAPHRODITIC AND CONNECTOR PLUG

BULKHEAD RECEPTACLE

ITT-EOPD INTERWORKS AGREEMENT #A10208
CLIN 0007-A003
CLIN 0007-A004

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(II)

TABLE OF CONTENTS

1.0 SUMMARY:

The plan is to design a hermaphroditic connector which will terminate six (6) channel cable developed for this contract. The connector and cable will be designed so that eight (8), one-kilometer cable assemblies in tandem will transmit signals without the use of repeaters. The cable plug shall be hermaphroditic and the receptacle shall terminate six (6) channel cable same as the plug. Both will be used in tactical time division multiplex communications systems. Operation will be at selected wave lengths from 6,000 to 10,600 angstroms for both analog and data transmission with data rates to 20 megabits per second, per kilometer. The cable will be manufactured in one(1) kilometer lengths and have a maximum attenuation of 5dB per kilometer. The connector coupling loss goal is 1.0dB for plug to plug connection and 1.5dB for plug to receptacle connections. Based on the critical design review, held at ITT Cannon Electric in July of 1979, a jewel/ferrule alignment concept will be used for the remainder of this contract. The capabilities of the jewel/ferrule alignment concept will be covered in the background data section of this plan. The connectors will be designed for use in tactical field conditions and therefore be rugged, easy to couple and uncouple, be coated with a non-reflective finish which is environment resistant, and sealed so that it will not allow water to enter the connector or the cable end.

2.0 OBJECTIVES:

The design objective is to meet or exceed the requirements for hermaphroditic cable plug and bulkhead mount receptacle as stated in the Technical Guidelines, Ultra Low Loss Optical Fiber Cable Assemblies, ITT-EOPD Interworks Agreement #A10208. The design plan will address the requirements in the order listed. Conformance to and deviation from the technical guidelines will be addressed, in this design plan, on every requirement with background data to support major design features.

2.1 FIELD REPAIR:

A connector will be designed which is capable of assembly to the cable by trained technicians in a depot or mobile repair van. The design shall not require the use of molding or potting techniques for accomplishing the assembly. Termination costs, complexity, reliability, ease of assembly, and performance will be considered. Ref: Cable Termination Procedure-para. 3.0

2.2 CABLE PREPARATION:

Reference cable termination procedure., paragraph 3.0

2.3 CABLE STRAIN RELIEF:

The connector design will contain a cable strain relief and strength member clamp which will isolate the optical fibers and connector termini from direct tensile, torsional, and bending forces applied between the connector and cable. The cable clamp will incorporate a taper fit clamp and ring which will capture the kevlar strength member of the cable. The inner clamp provides a radius about which the kevlar is dressed. The outer ring fits over the inner to capture the kevlar.

This clamp has been tested with ITT-EOPD cable design III and proved to hold more than the 181.44 kg (400 lbs) required. The connector clamp nut will prevent loosening from vibration, temperature extremes, or shock. Ref: figure I-a; additional reference to the kevlar clamp may be found in paragraph 4.2

The cable grip (fig. I-b) will provide resistance to cable twist and forces which tend to push the cable towards the interface of the connector. It clamps onto the jacket of the cable as the slotted fingers are forced inward by the tapered inside diameter of the nut. The closed diameter of the fingers is controlled to prevent too much or too little clamping force by bottoming the nut against the clamp bushing. The cable grip will be modified from previous designs so that all clamping action will be performed prior to insertion into the connector shell. This will simplify the assembly and dis-assembly of the connector. The strain relief spring, fig. I-c, will be designed to prevent cable damage when flexure occures at the cable exit of the connector. The spring will be improved over previous designs to provide greater resistance to bending. A chamber, fig. I-d, between the rear of the terminus assembly and the end of the cable jacket will be designed to allow movement of the jewel/ferrules rearward during mating. The chamber will also allow for fiber pull back when the tensile load is applied to the cable, as was observed in previous cable retention tests. This "flex chamber" will allow for relatively large bend radius of the moved fiber in order to reduce macro bend losses. Exact length of the flex chamber will be determined from fiber flex test data and overall connector length considerations. Reference: Background Data, paragraph 4.2

2.4 MATING CHARACTERISTICS

The mating faces of the connector shall be optical with minimal cross-talk between adjacent optical paths and coupling loss between connectors. The optical mating faces will be suitably protected to prevent permanent degradation of light transfer between mating connectors as a result of repeated matings and unmatings, exposure to moisture, water immersion, dirt, dust, sand, salt spray, and temperature extremes. The interface of the jewel/ferrules will be washable with water or lens cleaning fluid. It shall not be readily excessible to brushes, cotton tip applicators, cloths, probes, or other cleaning devices which could scratch or chip the ends of the

fibers. In event foreign matter enters the guide sleeve of the terminus, which cannot be washed out, the connector can and should be disassembled by a trained technician, fiber ends cleaned and inspected for damage and then reassembled. Because of the size and position of the male and female sleeves in the connector, only extreme misuse would cause this condition. The interface is scoop proof and the termini are protected by the shell.

2.4.1 Connector Plug, Hermaphroditic:

The connector mating face and positive locking coupling device will be completely hermaphroditic to permit termination of both ends of the cable with identical connectors. The coupling device will turn with respect to the connector shell. The coupling mechanism will be one-quarter(¼) turn ramp coupling nut and anti-vibration positive clicking device incorporated with it. (fig. I-e) The coupling mechanism is currently being used in another military connector manufactured by ITT Cannon Electric.

2.4.2 Bulkhead Receptacle Design Objectives:

The mating characteristic of the mated bulkhead receptacle will be essentially the same as stated for the cable plug with exception that the coupling device will not be free turning with respect to the connector shell. The receptacle shall have a bulkhead, D-hole type mounting with jam nut, lock washer and "O" ring panel seal. The receptacle will mount in a maximum .0064 meter (.250 inch) thick panel. The bulkhead receptacle will terminate same cable as the cable plug. This configuration is not required by the technical guide lines but makes environmental testing easier to accomplish. The fibers therefore will not be individually removable. The design does allow for "pigtail" fiber termination with exchange of cable clamp hardware for a larger opening clamp nut and sleeve. No moisture seal would be included in the "pigtail" fiber termination version.

2.5 MATERIALS AND FINISHES:

The material and finishes for plug and receptacle will be as follows:

2.5.1 Shell Hardware:

Aluminum with cadmium over nickel plating. 6000 series aluminum was chosen based on its high corrosion resistance, good strength which can be increased by heat treatment, easy formability and machinability, and availability. The finish, cadmium .0004 minimum thick over electroless nickel .0003 minimum thick, was chosen for corrosion resistance. This is the same finish which is used on military connectors made by Cannon Electric and has proven to exceed the 48 hr. salt spray requirement of the technical guide lines. An olive drab chromate finish over the cadmium makes the connector suitable for military field use.

2.5.2 Terminus Components:

("Clicker" hardware, spacer post, and strain relief string): Corrosion Resistant Steel, Passivated. 300 series corrosion resistant steel was chosen for strength and corrosion resistance in an unplated state. The terminus design requires very tight tolerance and sees a frictional force during the mating and unmating. A plated surface would exhibit high wear and possible flaking to contaminate the interface of the fibers. "Clicker" hardware sees very high forces during mating and would effect performance after the required 1,000 cycles durability and 48 hrs. salt spray. The spacer post may be changed after aluminum stress analysis is performed on the assembly. The strain relief spring is easily formed with corrosion resistant steel wire and has proven, on previous design, to be functional.

2.5.3 Grommet and "O" Rings-Silicone Rubber:

Chosen for its large range of service temperature particularly the low temperature requirement of -57° C., silicone rubber also provides very good sealing properities in static seals such as is found in this design. The 40 durometer silicone rubber used in the grommet provides a seal which also does not restrict the alignment of the terminus sleeves.

2.5.4 Cable Grip:

Beryllium copper with cadmium over nickel plating,heat treated to spring temper. Chosen for ease of manufacture in the half hard state, and spring quality in the heat treated state. The cable grip sees limited wear and therefore plating does not cause functional problems.

2.5.5 Lock Washer - Internal Tooth:

Phosphor bronze with cadmium plating. Chosen because of availability and proven use. Phosphor bronze has spring qualities when cold worked and is highly resistive to corrosion from salt spray. Cadmium adds to this corrosion resistance.

2.5.6 Jewel/Ferrule - Ruby or Saphire:

Chosen as a bearing interface material which is manufactured to very tight tolerances both in size and concentricity. Jewels are purchased in various inside diameters so that by selecting the size hole which closely matches the fiber diameter the concentricity between fiber and ferrule can be maintained.

2.5.7 Epoxy:

The present epoxy being used to terminate jewel/ferrule is Epotek #331, but it is planned to try powdered epoxy pellets to improve the termination process.

3.0 CABLE TERMINATION PROCEDURE:

Cable termination for this connector is a relatively simple process. The facet that tends to complicate it lies in the fact that all six (6) fibers must be terminated the same length, and therefore one imperfect termination makes it necessary to re-terminate the others. Service loops in this fiber causes bend radiation loss which is reported in section 4.2

The basic cable termination procedure will follow these steps:

Step 1: Identify hardware and inspect for general condition and quantities.

Step 2: Clean outer jacket of the cable up to two (2) meters from the square cut end.

Step 3: Assemble the hardware onto the cable in the following order.

Clamp nut, strain relief spring and clamp backplate assembly, large and small "O" rings, flat washer, cable grip and clamp assembly, and spacer assembly. Push all this hardware down the cable and tape in place one and one-half($1\frac{1}{2}$) meters from the end to keep it out of the way.

Step 4: Trim back outer polyurethane jacket kevlar strength member and polyurethane inner jacket a predetermined length exposing the six (6) buffered fibers and a center spacer the same size as the buffered fibers. Cut back the center spacer and make sure all fibers are the same length.

Step 5: Terminate one fiber complete at a time. Assemble the terminus rear body and spring onto the buffered fiber and tape them back away from the end. Strip buffer from fiber, clean the exposed fiber,assemble a ferrule(with the smallest jewel which will fit) on the fiber and epoxy in place. Grind, polish, and inspect end of fiber. Ref: section 5.0

Step 6: Assemble ferrule "O" ring on to ferrule and sleeve over assembly to protect end face of fiber.

Step 7: Terminate all six fibers the same as steps 5 and 6.

Step 8: Measure from back of terminus to jacket and mark. Trim outer polyurethane jacket back to expose the kevlar strength member of the cable. (Note: Take care not to cut the kevlar as this effects the ultimate strength of the assembly.)

Step 9: Untape the clamp hardware from the jacket and bring the spacer assembly and cable grip and clamp assembly up towards the termini. The kevlar must be brought back of the clamp ring portion of the spacer assembly and dressed around the kevlar clamp. Press the clamp and ring together lightly and insure even distribution of kevlar around the clamp.

Step 10: Assemble termini into backplate slots arranging male and female sleeves into their proper positions. Slide terminus collar over the front of the termini then assemble the connector grommet over all termini.

Step 11: Re-check position of dressed kevlar strands then position the cable in relation to the spacer assembly so that the proper service bend exists. Press kevlar clamp and ring together. Using standard wrenches, tighten cable grip onto cable making sure no slack exists in the exposed kevlar. The hex-nut should be bottomed against the kevlar clamp.

Step 12: Bring remaining hardware up to cable grip hex-nut and slide the assembly into the connector shell. Keys in the shell will align the terminus backplate and hold the clamp backplate when the clamp nut is tightened.

Step 13: Inspect cable interface to assure terminus orientation and position. Tighten clamp nut.

* Termination procedure of jewel/ferrule is described in detail in section 5.2

4.0 BACKGROUND DATA SUMMARY:

This connector is being designed by taking the results of tests, conducted on other connectors and cable, and applying the knowledge gained to its best application. The present program follows many others dealing with fiber optic connectors and fiber optic cable. The data following reflects this history.

4.1 JEWEL/FERRULE ALIGNMENT CONCEPT:

The cable chosen for this program is a six-channel fiber optic cable. Each fiber is a graded index glass fiber with the following dimensions:

Buffer diameter	1 mm
Fiber diameter	$125 \pm 5\%$ μm
Core diameter	50 μm
Numerical aperture	$>$ .25

The jewel/ferrule alignment concept aligns the core of the mating fibers and brings the polished faces extremely close without touching. Since the glass is brittle, butting ends could shatter during shock or vibration to the connector. When the fiber end is polished during the termination process, the glass fiber is erroded away faster than the jewel bearing which surrounds it leaving the fiber just below the jewel face. The jewel then acts as a bearing surface for the load created by the terminus spring which forces the fiber forward to insure the proximity of the ends. This system results in extremely low gap loss, typically less than .2dB. The exact loss depends on the amount of polishing it receives. Angular loss is the second alignment problem. The jewel/ferrule alignment concept supports one ferrule 9.398mm min. (.370 inch) min. and the other 7.950mm (.313 inch) minimum within the male guide sleeve. With a maximum gap, between ferrule and sleeve, of .010mm (.0004 inch) the result maximum angular mis-alignment is less than one eigth (1/8) of one degree ($< 1/8^{\circ}$) a angular loss of less than .05dB.

Lateral mis-alignment accounts for the largest percentage of loss in the jewel/ferrule concept. The variation in size of the fiber does not allow using one jewel hole diameter and cost of purchasing jewels in one micron increments is not practical on a production basis, therefore the figures listed below reflect maximum gap between fiber and jewel with jewels sized in five (5) micron increments. The other figures are based upon standard jewel/ferrule component tolerances of parts being used by ITT Cannon Electric at the present time.

Max. jewel hole to fiber O.D. gap	5 µm
Jewel I.D. to O.D. T.I.R.	3 µm
Ferrule I.D. to O.D. T.I.R	10 µm
Ferrule O.D. to male guide sleeve gap	10 µm
	28 µm

Statistically the most probable excentricity is L:

$$L = \left[5^2 + 3^2 + 10^2 + 10^2\right]^{\frac{1}{2}} = 15.3\ \mu m$$

This corresponds to a fiber core displacement of 31% and a lateral alignment loss of 2.1dB. * The total extrinsic loss of the connection using the jewel/ferrule alignment concept is:

	dB
Gap Loss	< .20
Angular Loss	< .05
Laterial mis-alignment loss	2.10
** Fresnel Loss	.30
	< 2.65

* Improved performance is possible thru closer jewel fiber sizing and improvement of ferrule and guide sleeve manufacturing tolerances. As part of this program, Cannon Electric will investigate manufacturing processes which will lessen the lateral misalignment losses.

** Fresnel loss is inherent in all fiber connections which do not use an index matching liquid or anti-reflection coating on the fiber ends and are not used in this design.

(Cont'd)

4.1 Conclusion:

Less than 1dB as a goal for the jewel/ferrule alignment concept is not practical but less than 2dB is.

4.2 <u>FLEX CHAMBER DATA</u>:

The connector flex chamber design is based upon testing done at the start of this program and testing done as part of other programs The following quotes are from the final technical report, "Connectors for Optical Fiber TDM Cables", R&D Technical Report-ECOM DAA7-76-1357-1.

<u>"4.3.3) FIBER BEND RADIATION LOSS EVALUATION</u>

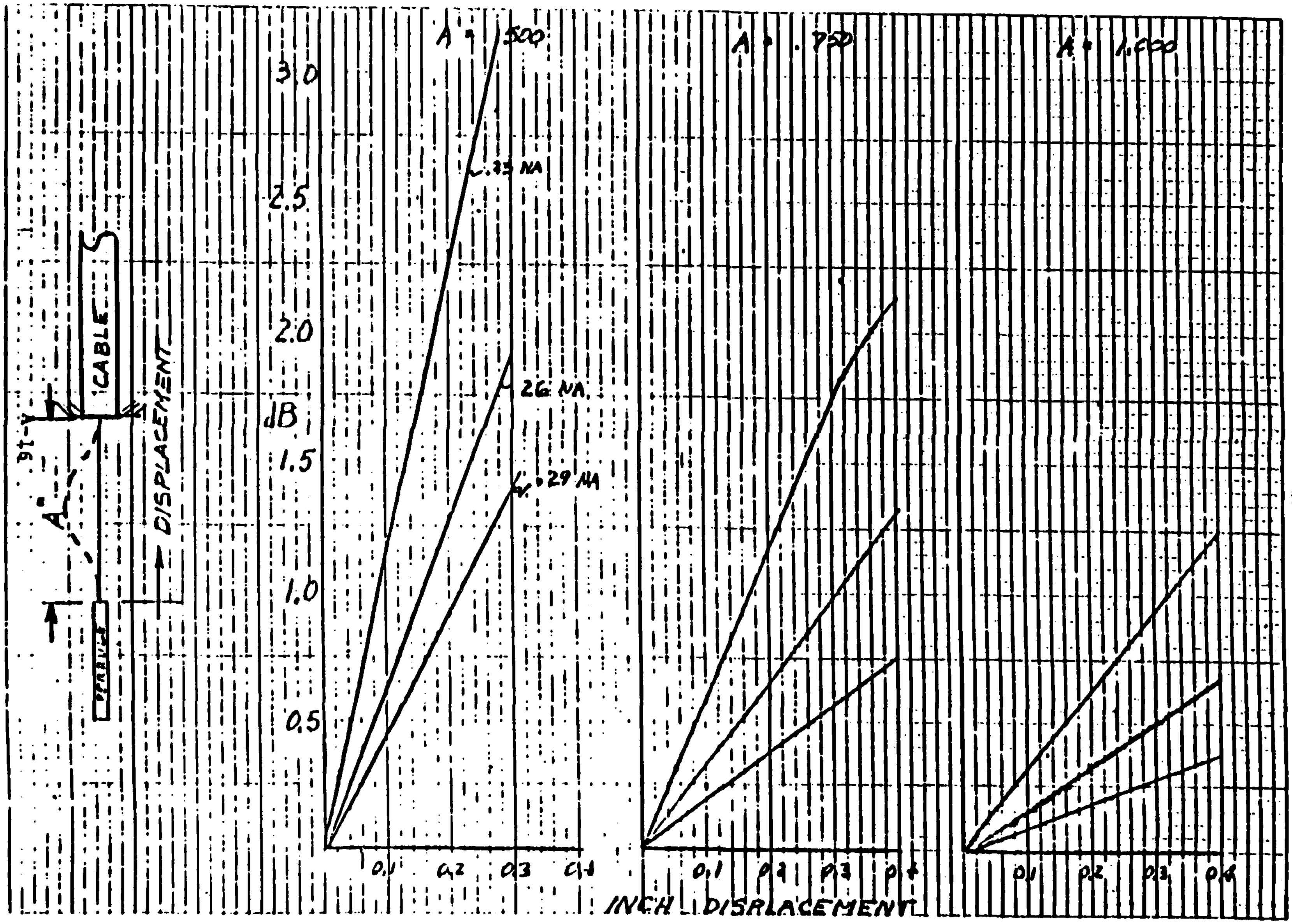
The need to determine the attenuation as light propagates through a curved fiber is due to the connector functional design."

" As two connectors are mated, a means must be provided to accumulate the varying manufacturing dimensional tolerances of the mating components. Two basic design requirements coexist: 1) the mating fibers must abutt each other with minimum separation and, therefore, must be spring loaded to accummulate mating hardware tolerances (shells, coupling nuts) and 2) the cable strength member (Kevlar strands)must be clamped at the rear of the connector.- Since the cable cannot move relative to the connector body (due to clamping of the Kevlar), and the ferrules compress their springs upon mating; the fiber between the rear of the ferrule and the Kevlar clamp position must be allowed to flex. This portion of the connector is referred to as the flexure chamber." (Refer to section 5.0 fig. I-d for drawings of the flexure chamber).

"As the project progressed, it was recognized that considerable attenuation was caused by the flexure chamber concept. The design of the six-channel connector's flex chamber (it's length) was based upon testing a sample ITT fiber, early in the project. This turned out to be in error due to variations in numerical aperture of subsequent fibers. The attuation is a function of the N.A. as well as the bend radius. The curves of fig. ten & eleven (11) represent the significant data empirically produced with 55/125μm ITT fiber. The flex chamber length can be determined through use of this data and budgeting of the allowable extrinsic coupling loss."

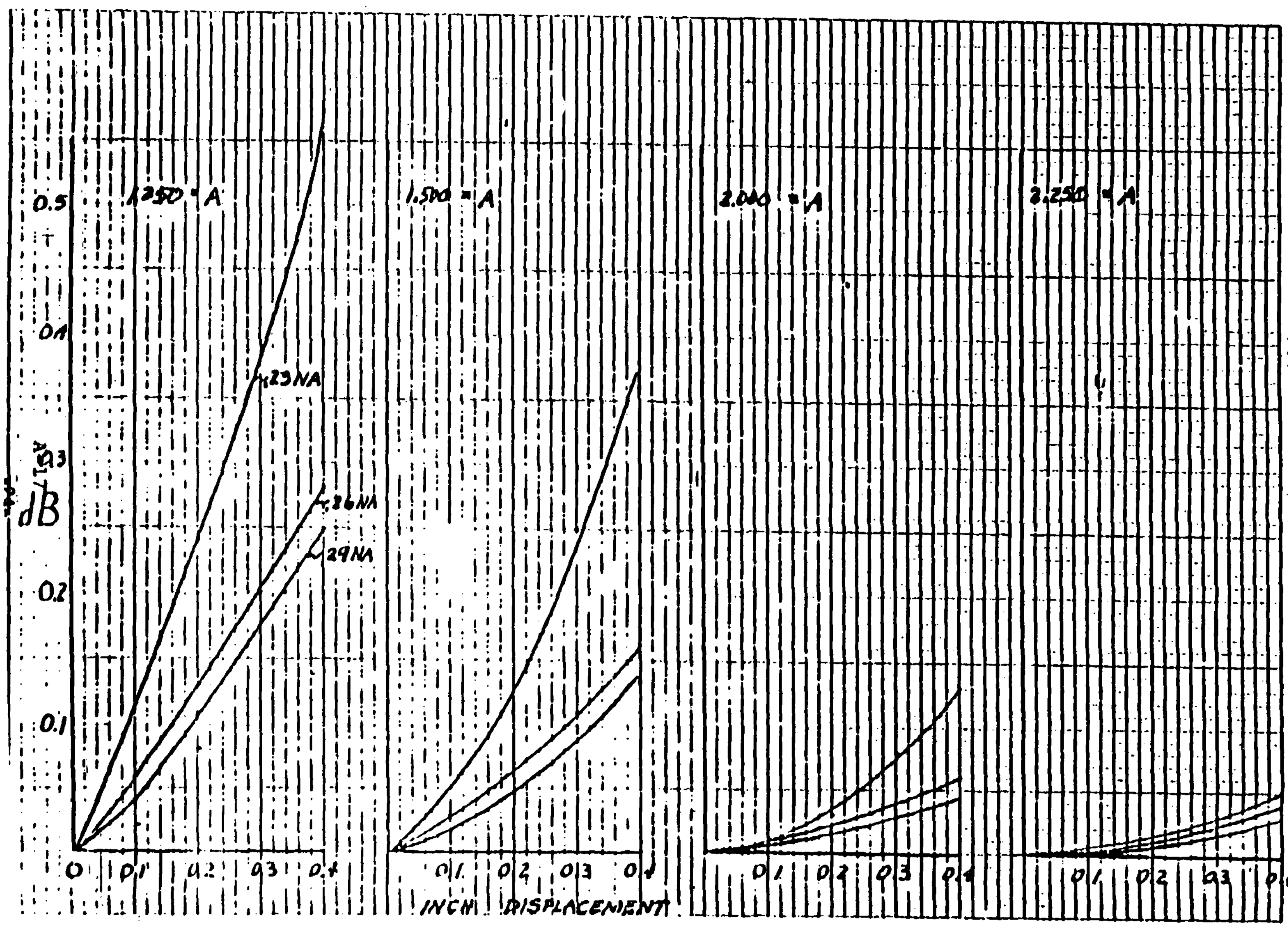
" The coordination was accomplished and ITT cable design III was tested for retention. The cable strength member was terminated to an actual six-channel connector; the ferrules were omitted and the fibers were allowed to extend through the connector, exposing then. The shell of the connector was machined to provide windows to view the kevlar clamp and fibers during the test. Standard tension testing equipment and techniques were employed. The termination design met specification by holding at 400 pounds.

"The load was increased in 100 pounds increments; fiber movement was noticed. The cable stretches under load (kevlar is rated at 1% elongation at 500 pounds) causing the fibers to unwind from their helically wrapped position. The fibers moved aft within the connector 0.075 inch at 400 pounds as the cable stretched behind the connector. Because of this movement, it was decided to provide a fiber service length of 0.200 inch within the flex chamber to preclude the ferrules from being pulled upon and separating."



A = 500
.25 NA
26 NA
.29 NA
A = 750
A = 1,000
3.0
2.5
2.0
dB
1.5
1.0
0.5
0.1
0.2
0.3
0.4
INCH DISPLACEMENT
CABLE
DISPLACEMENT
A

FIGURE 10



A17
dB
0.5
0.4
0.3
0.2
0.1
0
1.250 = A
1.500 = A
2.000 = A
2.250 = A
.23NA
.26NA
.29NA
0.1
0.2
0.3
0.4
INCH DISPLACEMENT

FIGURE II

5.0 VISUALIZATION DATA:

FIGURE I	CONNECTOR PLUG, HERMAPHRODITIC
FIGURE II	CONNECTOR PLUG, BULKHEAD RECEPTACLE
FIGURE III	TERMINUS ASSEMBLY

5.1 P A R T S   L I S T S

PARTS LIST:
FOR: 111270-0003
CABLE PLUG

	ITEM
SHELL PLUG	1
COUPLING NUT	2
CLAMP NUT	3
GROMMET	4
BACKPLATE, TERMINUS	5
PIN, SPACER (3x)	6
CLAMP SLEEVE	7
KEVLAR CLAMP	8
WASHER	9
CABLE GRIP HEX NUT	10
CLAMP BACKPLATE	11
STRAIN RELIEF SPRING	12
RING, CLICKER RETAINER	13
TERMINUS COLLAR	14
CABLE GRIP	15
O-RING, CABLE	16
O-RING, SHELL	17
WASHER, LOCKING CLICKER	18
SPRING, WAVE	19
MALE TERMINUS p/n 045-9506-001	20
FEMALE TERMINUS p/n 045-9505-001	21

PARTS LIST
FOR: 111271-0003
RECEPTACLE

	ITEMS
SHELL, RECEPTACLE	1
GROMMET	2
BACKPLATE, TERMINUS	3
PIN, SPACER (3x)	4
CLAMP SLEEVE	5
KEVLAR CLAMP	6
WASHER	7
CABLE GRIP HEX NUT	8
CLAMP BACKPLATE	9
STRAIN RELIEF SPRING	10
NUT, HEX JAM	11
TERMINUS COLLAR	12
CABLE GRIP	13
CLAMP NUT	14
O-RING, CABLE #2-107	15
O-RING, SHELL #2-119	16
O-RING, MTG #2-138	17
LOCKWASHER #1954-00	18
MALE TERMINUS p/n 045-9506-001	19
FEMALE TERMINUS p/n 045-9505-001	20

PARTS LIST
FOR: 045-0506-001
TERMINUS ASSEMBLY, MALE

SLEEVE, MALE	1
BODY, REAR	2
O-RING #2-003	3
SPRING	4
JEWEL/FERRULE ASSEMBLY	5

PARTS LIST

FOR: 045-9505-001

TERMINUS ASSEMBLY, FEMALE

SLEEVE, FEMALE	1
BODY , REAR	2
O-RING #2-003	3
SPRING	4
JEWEL/FERRULE ASSEMBLY	5

5.2 JEWEL/FERRULE TERMINATION INSTRUCTIONS

The following sheets contain the jewel/ferrule termination procedures for the three (3) series of connectors produced by ITT Cannon Electric (FOT, FOS, FON). The procedure for termination of the jewel/ferrules for this project will be similar.

ASSEMBLY OF FERRULES ON SINGLE FIBERS

KITS:

Description	Part Number
FOT Termination Kit	320-7009-000
FOS Termination Kit	320-7008-000
FON Termination Kit	320-7014-000

MATERIALS:

Description	Part Number	FOT	FOS	FON
Adhesive, Epoxy, Fiberpotting	970-0006-975	X	X	X
Cleaner (Acetone and Freon)	Not Supplied			
Kim Wipes	Not Supplied			
Q-Tips	Not Supplied			
Spare Parts Kit, FOT	320-7012-000	X		
Spare Parts Kit, FOS	320-7011-000		X	
Spare Parts Kit, FON	320-7015-000			X

EQUIPMENT:

Description	Part Number	FOT	FOS	FON
Stripper, Fiber Buffer (0.010") Blue Handle For ½mm. Buffer	980-0005-548	X	X	X
Stripper, Fiber Buffer (0.016") White Handle for 1 mm. Buffer	980-0005-549	X	X	X
Blades, Razor, Single Edge	980-0005-547	X	X	X
Gun, Heat, 475 Watts (110VAC, 60 HZ)	995-0001-988	X	X	X
Tool, Epoxy, Insertion	274-7058-000	X	X	X
Bottles, Drop Dispenser	980-0005-550	X	X	X
Fixture, FOS Alignment	111278-0000		X	
Tool, Strain Relief	317-1564-000		X	
Micrometer, Meter	Not Supplied			

CABLE DESCRIPTION:

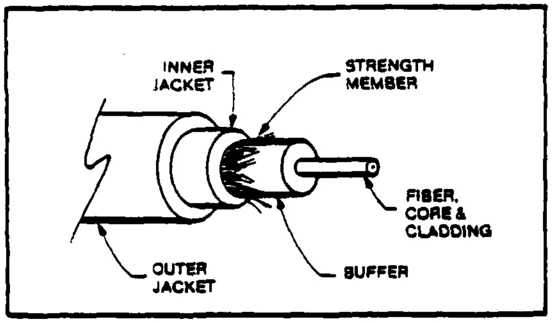


FIGURE 1.

PROCEDURE:

1) Strength member cable termination — using razor blade, remove outer and inner jacket of the cable. Do not nick strength member. For the FOS connector, a minimum of 2" of unstripped fiber must project from the cable clamp member.

CAUTION: Insure that all necessary components are installed on the cable prior to strength member termination. Uniformly dress back the strength member over the strain relief, and install the clamp ring, using strain relief tool (P/N 317-1564-000). See Figure 1 &2.

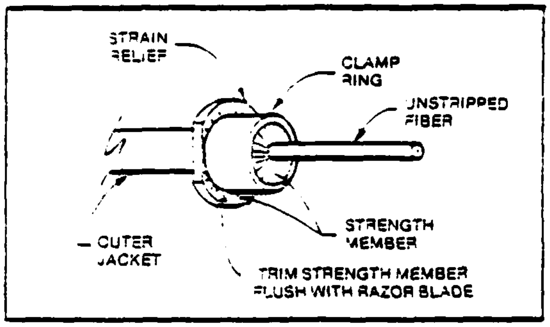


FIGURE 2.

2) Fiber Preparation — buffer removals accomplished by using the stripper, fiber buffer (P/N 980-0005-548 or 980-0005-549.) Buffer strip lengths for single fiber connectors are as follows:

Connector	ITT/Cannon Dwg. No.	Strip Length (+0.030)
FOT (plug and receptacle)	111089-0000	1"
FOS-6 plug	1172Y	7/8"
FOS-2 short receptacle	111110-0004	1"
FOS-0 long receptacle	1173Y	7/8"
FON-FJ	111201-0001	7/8"

3) Oil removal — remove the silicone oil from the stripped fiber by dipping it in acetone, wipe it clean with Kim Wipes. Care should be taken (from this step on) not to break the exposed fiber.

4) Fiber measurement — measure the fiber diameter in microns with a metric micrometer.

5) Ferrule selection — select a jeweled ferrule whose graded inside diameter is as close to the fiber diameter as possible. The closer the fit, the better the performance. The following tabulation correlates ferrule Part No.'s with connector types:

Connector	Ferrule Part No.
FOT-F-1	070-0037-XXX
FOT-F-2	070-0034-XXX
FOS-F	070-0035-XXX
FON-FJ	070-0036-XXX

NOTE: XXX denotes jewel inside diameter in microns.

NOTE: The support sleeve (P/N 252-1251-000) is used inside the FOT-F-1 ferrules for ½ mm buffered fiber. (See Fig. 3.) Install the support sleeve, projecting approximately .280 in from the ferrule shoulder, prior to the jewel-ferrule final assembly.

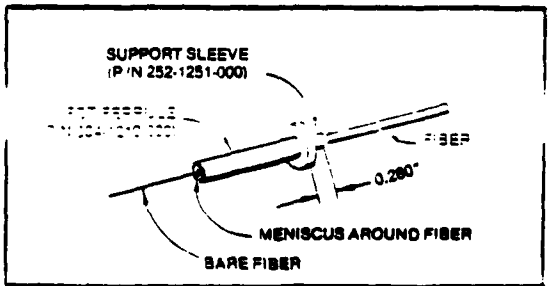


FIGURE 3.

GRINDING AND POLISHING PROCEDURE FOR SINGLE FIBER TERMINATION

KITS:

Description	Part Number
FOT Termination Kit	320-7009-000
FOS Termination Kit	320-7008-000
FON Termination Kit	320-7014-000

MATERIALS:

Description	Part Number	FOT	FOS	FON
Suspension, Polishing, Alumina 1.0 Micron (Linde C, 6 Fl. oz.)	980-0005-544	X	X	X
Suspension, Polishing, Alumina .05 Micron (Linde B, 6 Fl. oz.)	980-0005-545	X	X	X
Bottle, Drop Dispenser (2)	980-0005-550	X	X	X
Fluid, Lens Cleaning (1 Fl. oz.)	970-0006-984	X	X	X
Kim Wipes	Not Supplied			

EQUIPMENT:

Description	Part Number	FOT	FOS	FON
Brush, Cleaning	980-0005-574	X	X	X
Disk, Abrasive	995-0001-990	X	X	X
Fixture, Polishing FOT	111258-0000	X		
Fixture, Polishing FOS	111259-0000		X	
Fixture, Polishing FON	111296-000			X
Cloth, Polishing Texmet	980-0005-546	X	X	X
Block, Lapping Base — B	317-1561-000	X	X	X
Block, Lapping Base — C	317-1562-000	X	X	X
Cutter, Glass Fiber (Alumina)	317-1563-000	X	X	X
Microscope, 200X	995-0001-993		Optional	

NOTE: The following procedure applies to stepped and graded index silica core fibers.

PROCEDURE:

1) Cleaving — Carefully scribe the fiber projecting from the face of the epoxied and cured ferrule with the glass fiber cutter (P/N 317-1563-000). See Figure 1 for location of the scribe mark. Break the fiber gently by applying a light force at the end of the fiber, see Figure 1.

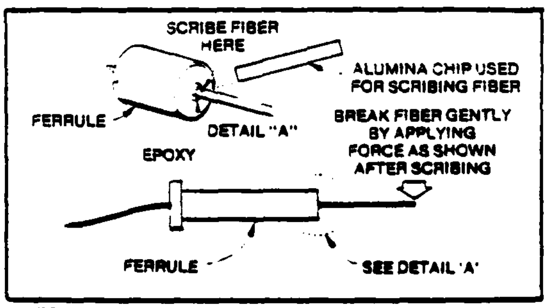


FIGURE 1.

2) Cleaved fiber examination — backlight the opposite end of the fiber and observe the cleaved fiber using 200X magnification. If the epoxy and jewel is illuminated with scattered light and the fiber core is cracked behind the jewel, then remove and replace the ferrule per the assembly of ferrules on single fibers procedure. If the light is not scattered behind the jewel and the fiber end is not perfectly round, but is cracked, then a surface flaw is indicated, which can be removed by grinding and polishing.

3) Reinforce the cleaved end — apply a small bead of epoxy over the cleaved end of the fiber as shown in Figure 2. Cure the epoxy as explained in the assembly of ferrules procedure.

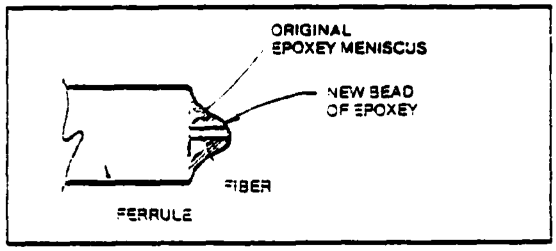


FIGURE 2.

4) Grinding — Install the ferrule in the appropriate polishing fixture: P/N 111258-0000 for FOT, P/N 111259-0000 for FOS, and P/N 111296-0000 for FON. **NOTE:** For the FOS-2 ferrule: use the spare yokes (P/N 281-3500-001) and end cap (P/N 025-9552-000) to adapt the ferrule to the polishing fixture. Position the ferrules per Figures 3 & 4.

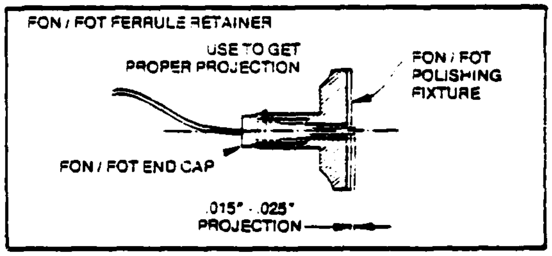


FIGURE 3.

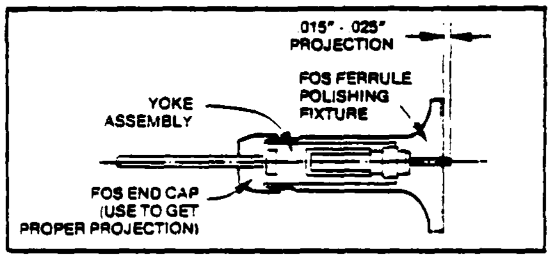


FIGURE 4.

If the face of the fiber is not perfectly round or is cracked, grind the ferrule using light, normal pressure on the abrasive disk (P/N 995-0001-990) as shown in Figure 5. Make sure the abrasive disk is on a flat, solid surface. Use cutter during the grinding process. When a round and crack-free full core is obtained, gradually proceed to grind the ferrules in the patterns shown in Figure 6, until the fiber is flush with the surface of the jewel.

If the core observed in Step 2 is round and free of cracks, grind the ferrules on the abrasive disk per the pattern shown in Figure 6, until the fiber is flush with the surface of the jewel, or slightly concave.

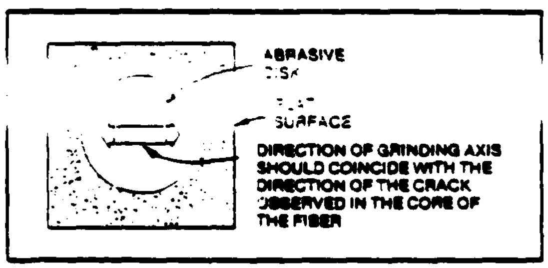


FIGURE 5.

ULTRA LOW LOSS

FIBER OPTIC CABLE ASSEMBLIES

CONNECTOR TEST PLAN

CONTRACT DAAB07-78-C-2922

ITT PROJECT 36027

Prepared for:

U.S.A. CORADCOM
Fort Monmouth
New Jersey 07703

Prepared by:

ITT Electro-Optical Products Division
7635 Plantation Road, N.W.
Roanoke, Virginia 24019

Approved by:

F. R. McDevitt, Director,
Fiber Optics R&D and Systems

Date: April 3, 1981
Doc Id No: 81-12-10

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1.0 INTRODUCTION

This test procedure describes test methods and equipment for evaluating the performance of six-channel, single-fiber optical cable plugs and bulkhead receptacles under environmental and mechanical exposures typical of military tactical field applications. This procedure covers the connector evaluation section, paragraph 3.2.5, of "Technical Guidelines for Ultra Low Loss Optical Fiber Assemblies."

2.0 APPLICABLE DOCUMENTS

The following specifications and documents form a part of this procedure to the extent specified:

a. MIL-STD-202E, Notice 5, dated 4 October 1978, Test Methods for Electronic and Electrical Component Parts

b. MIL-C-45662A, dated 9 February 1962, Calibration System Requirements

c. MIL-STD-1344A, dated 1 September 1977, Test Methods for Electrical Connectors

3.0 TEST SAMPLE DESCRIPTION

Six cable plugs and six bulkhead receptacles will be supplied for test. The plugs and receptacles will be paired and assigned sample numbers 1 through 6 for identification and for determining the appropriate test sequence. After assembly, each connector half will have 10 m of optical cable to enable the connectors to be installed inside test chambers without disturbing the connections to the optical test apparatus. The input and output ends of the cable will be cladding mode stripped. The input end will be permanently attached to the optical power transmitter.

4.0 GENERAL REQUIREMENTS

4.1 Calibration of Test Equipment

All test equipment to be used in the performance of these tests will be calibrated in accordance with MIL-C-45662A. Each item of test equipment will bear a calibration label reflecting the instrument control number, the date of the last calibration, and the date the instrument is next due for calibration. Equipment calibration procedures will be maintained on file in the calibration laboratory.

4.2 Test Equipment Tolerances

Unless otherwise specified, the test equipment will be capable of indicating and controlling test conditions within the following tolerances:

a.	Temperature	2°C
b.	Force	2%
c.	Optical power ratio	0.1 dB
d.	Torque	2%

4.3 Test Conditions

Unless otherwise specified, all tests required by this procedure will be performed under the following environmental conditions:

a.	Temperature	15°C to 35°C
b.	Relative humidity	30 to 80%
c.	Barometric pressure	94 to 108 kPa

4.4 Action in the Event of Failure

In the event that a specimen fails a test requirement specified herein, testing will be stopped if it is considered that completion of the test or succeeding tests will mask the cause of failure. ITT Electro-Optical Products Division (EOPD) will be notified of the problem in writing.

4.5 Documentation

A formal test report, including test data sheets, will be furnished at the completion of testing. All variable test data will be recorded. As a minimum, the report will include:

a. Title page
b. Table of contents
c. Purpose
d. Conclusions
e. References
f. List of test equipment
g. Laboratory data sheets

4.5.1 Recorded Data

All measurements will be recorded to as many significant digits as are meaningful under the accuracy limits of the test equipment used. All data will be recorded on appropriate data sheets.

The ambient test conditions (temperature, relative humidity, and barometric pressure) and the date will be recorded on the data

form. If a data sheet covers measurements performed on more than 1 day, the ambient conditions and date for each day covered will be included on the data sheet.

Only original laboratory test data or a direct image thereof will be submitted as the final test document. Data sheets will not be rewritten. In the case of errors accidentally recorded on the data forms, the erroneous data will be lined out by a single line. The corrected information will be inserted, and the correction will be initialed by the technician making the change.

Test data will include, whenever applicable, the following details:

a. Diagrams, sketches, or photographs of each test setup

b. Electrical hookups which are peculiar to the test program or which might prevent duplication of the test method or results if not supplied

c. The orientation of samples to the direction of force imparted during any physical test such as flex or twist

d. Any fixturing used for mounting the test samples for any of the tests covered herein

e. A detailed explanation of how the test was performed

f. All data recorded during performance of the test

4.6 Disposition of Test Samples

Upon completion of the testing required herein, the test samples will be individually bagged along with suitable identification of the test sample number and the laboratory project number and shipped to ITT EOPD.

5.0 TEST SEQUENCE

The test samples described in Section 3.0 will be subjected to the tests listed in Tables 5.0-1 and 5.0-2 according to the sample number assigned at the time of submission. The individual test samples will be tested in the sequence of the numbers listed in the column under that sample number.

Table 5.0-1. Test Sequence.*

Test Name	Para	Sample Numbers 1	2	3	4	5	6
Examination	6.1	1,4, 7,10	1,4, 7	1,4, 7,10	1,4, 7	1,4	1,4
Coupling loss	6.2	2,5, 8,11	2,5, 8	2,5, 8,11	2,5, 8	2,5	2,5
Mating durability	6.4	3	3	3	3	-	-
Immersion	6.6	6	-	6	-	-	-
Cable retention	6.9	9	6	-	-	-	-
Flex life	6.10	-	-	9	-	3	-
Twist	6.11	-	-	-	6	-	3
Crosstalk	6.12	12	9	-	-	-	-

*Each connector pair has a unique test sequence, i.e., sample number 6 will undergo the following sequence of tests: examination, coupling loss, twist, examination, and coupling loss.

Table 5.0-2. Summary of Quantity of Tests.

Test Name	Sample Numbers	Repetitions
Examination	All	18 (6 connectors)
Coupling loss	All	18 (6 connectors)
Mating durability	1,2,3,4	4 (4 connectors)
Immersion	1,3	2 (2 connectors)
Cable retention	1,2	2 (2 connectors)
Flex life	3,5	2 (2 connectors)
Twist	4,6	2 (2 connectors)
Crosstalk	1,2	2 (2 connectors)

6.0 TEST METHODS AND REQUIREMENTS

This section of the test procedure defines the equipment and method for performing each of the tests specified in Section 5.0, Test Sequence. Each sample has its own unique test sequence as illustrated in Table 5.0-1.

6.1 Examination Test

The examination test is performed to determine what effects the mechanical or environmental tests may have had on connector components. This test is limited to visual indications of physical deterioration which can be observed without disassembly of the connectors. Unmating of the counterpart connector halves is not considered disassembly.

6.1.1 References

Refer to paragraph 3.2.5.2 of "Technical Guidelines for Ultra Low Loss Optical Fiber Assemblies."

6.1.2 Test Equipment

The test equipment will include a microscope capable of 5 X magnification.

6.1.3 Test Method

Upon initial submission to the test laboratory, all test samples will be accompanied by a certification of compliance from fiber

optic Quality Control that the materials, finishes, dimensions, and workmanship meet the requirements of the applicable Hughes drawings.

Whenever the examination test is specified in the test sequence, the test laboratory will examine the test samples under 5 X magnification for evidence of damage, physical deterioration, or any other condition which might have an effect on subsequent connector performance. The counterpart connector halves will be unmated to allow examination of the interface area of each connector half. Particular attention will be paid to the condition of the engaging ends of the fiber optic elements. The mating surfaces of the elements may be cleaned if the examination indicates the presence of dirt or other foreign material.

6.1.4 Test Data

The initial examination data sheet will indicate that the proper certification of compliance has been received for each test sample submitted for test.

All examination data sheets will include a written record of the condition of each test sample at the time of examination. This record shall also indicate whether cleaning of the mating surfaces of the connectors was required or performed.

6.1.5 Requirements

All test samples will be accompanied by the appropriate certificate of compliance showing pretest inspection acceptance by fiber optic Quality Control. All evidence of damage, physical deterioration, or other conditions which might affect the connector performance will be noted and recorded in the test data.

6.2 Coupling Loss

The term "coupling loss" is used in two contexts in this test procedure. In its first context, coupling loss is the measurement of the insertion loss of a mated connector pair. Insertion loss is the ratio of the optical power through a continuous length of optical fiber to the optical power through the same fiber after a connector has been installed. The insertion loss test may be performed only once on a given fiber because it requires a continuous length of fiber at the start.

In its second context, coupling loss is a measurement of the effects of mechanical or environmental stresses on the optical interconnection. This measurement is an extension of the insertion loss measurement. It is expressed as the ratio of the optical power through a continuous length of optical fiber to the optical power through the same fiber after a connector has been installed and the connector has undergone mechanical or environmental stress. The distinction between this measurement and the

insertion loss measurement is time. Both utilize the same initial optical power reading for the uncut fiber, but in the second context a significant period of time has elapsed between the initial uncut reading and the final inserted and conditioned reading.

Each coupling loss test setup consists of test fibers and one or more reference fibers permanently positioned in the output field of an optical transmitter. Test fibers will eventually be cut for installation of the test connector while reference fibers remain uncut for the duration of the test program. The reference fibers are included to monitor the output of the optical transmitter and provide a basis for compensating any changes which may occur in the transmitter power. All optical power readings are expressed as a ratio in decibels of the test fiber to the reference fiber.

The coupling loss measurement can be thought of as occurring in two phases. During the first phase, cable characterization, the uncut cable and reference fibers are installed on the transmitter for a series of optical power measurements to establish the initial power ratio for each fiber in the cable to the reference fiber. These values form the basis for all subsequent coupling loss readings.

When the characterization has been completed, the cable will be cut and a mating pair of connectors will be installed rejoining

the original fibers. A new set of optical power ratios can now be measured to determine the coupling loss for each fiber. The coupling loss will be the difference between the current power ratio for a given fiber and the power ratio obtained during the characterization phase.

Thus,

$$\text{Loss (dB)} = \text{current power ratio (dB)} - \text{initial power ratio (dB)} \qquad (6\text{-}1)$$

6.2.1 References

Refer to paragraph 3.2.5.1.1 of "Technical Guidelines for Ultra Low Loss Optical Fiber Assemblies."

6.2.2 Test Equipment

The test equipment will include items required by Hughes to perform tests.

6.2.3 Test Method

6.2.3.1 Cable Preparation

Prepare a 20 m length of optical cable supplied by ITT ECPD for each test sample using appropriate Hughes preparation techniques.

Prepare one cable for each of the six mated connector pairs in the test program. Prepare one additional cable to be used as a cable control sample during subsequent tests.

1.210

6.2.3.2 Cable Characterization

Connect the optical transmitter to a dc power source capable of supplying 300 mA at 12 to 15 V. Allow sufficient time for the transmitter to warm up before proceeding with any measurements. Tag or color-code each fiber at the end opposite the transmitter. This identification will be used throughout the remainder of the test program.

Install the reference fiber at the reference port of the optical power meter. Install one of the test fibers at the signal port of the meter. The meter will display the ratio in decibels between the test fiber and the reference fiber. Record the value displayed and move on to the next fiber. This measurement should be repeated for each fiber in the cable with respect to each of the reference fibers.

This entire process should be repeated periodically over a period of 24 to 48 h to determine if there are any fluctuations with respect to time in the fiber power ratios. The mean value of the initial optical power ratio for each test fiber will be used for all subsequent coupling loss measurements. Be sure that all measurements are stable and that there are no loose connections at the optical transmitter.

After characterization, the cable will be cut at the midpoint taking care to maintain individual fiber identification in the two

sections of cable. The plug and receptacle test connectors will be assembled onto the cable using the assembly procedures specified by Hughes. When the connectors are assembled and coupled, the original fibers should be in counterpart terminals in the plug and receptacle.

6.2.3.3 Coupling Loss

Connect the optical transmitter to a dc power source capable of delivering 300 mA at 12 to 15 V. Allow sufficient time for the transmitter to warm up to operating temperature before proceeding with any measurements. Connect the reference fiber to the reference port of the optical multimeter. Connect a test fiber to the signal port of the multimeter. Record the current power ratio (CPR) indicated by the multimeter. Repeat this process for each of the test fibers in the cable. Measure the current power ratios for each of the fibers in the cable control sample in a similar fashion.

Calculate the coupling loss in the following way. Obtain the initial power ratio (IPR) for each test fiber from the data recorded during characterization. Subtract the initial power ratio from the current power ratio to obtain the power ratio differential (PRD):

$$\text{PRD (dB)} = \text{CPR (dB)} - \text{IPR (dB)} \qquad (6\text{-}2)$$

If this is the first measurement of coupling loss after installation of the connector, then the coupling loss is equal to the PRD. Calulate the actual connector coupling loss by subtracting the control value from the PRD for each test fiber:

$$\text{Loss (dB)} = \text{PRD (dB)} - \text{control (dB)} \tag{6-3}$$

Equation 6-3 is performed to compensate for any changes in the optical transmission of the cable alone as the result of environmental exposure.

6.2.4 Test Data

The test data will include sample and fiber identification; the results of each measurement for IPR and CPR; sample calculations for PRD, control, and coupling loss; and the results of all calculations. In addition, any observations of sample condition or performance which might aid in interpreting the test result will be recorded.

6.2.5 Requirements

The coupling loss of a mated pair of connectors with each assembled to a length of cable will be measured on an individual optical channel basis. The objective is 1.5 dB.

6.3 Rotation (Deleted)

6.4 Mating Durability

Mating durability is intended to determine the ability of the connector to withstand repeated coupling and uncoupling as in normal service. This test produces the type of wear which the connector might experience during its service life.

6.4.1 References

Refer to paragraph 3.2.5.2.2 of "Technical Guidelines for Ultra Low Loss Optical Fiber Assemblies."

6.4.2 Test Equipment

The test equipment will include items required by Hughes to perform tests.

6.4.3 Test Method

Mount the receptacle connector to a simulated panel with its jam nut. Connect the optical transmitter to a dc power source capable of supplying 300 mA at 12 to 15 V. Allow sufficient time for the transmitter to warm up to operating temperature before proceeding with any measurements. Align and engage the counterpart plug with the receptacle and rotate the coupling ring until the connectors are fully engaged. Then rotate the coupling ring in the opposite direction to fully uncouple the connectors. Separate the two connector halves completely. Repeat this process for a total of 1000 mating and unmating cycles. No lubrication of the coupling devices during cycling is allowed.

On the first mating and on every 50 mating cycles thereafter, measure the CPR for each fiber in the connector. (These measurements are intended to verify continuity only and are not considered a formal coupling loss measurement.) Observe the condition of the coupling devices and optical mating surfaces throughout the exposure.

Upon completion of the required mating cycles, the connector mating faces may be cleaned using appropriate procedures before submission to the subsequent tests in the sequence.

6.4.4 Test Data

The data sheets for mating durability will contain sample identification, CPR readings for each fiber for each 50 cycles, and any observations of physical change or damage along with the number of cycles completed at the time of observation.

6.4.5 Requirements

Counterpart connectors will be capable of meeting the requirements of succeeding tests after 1000 mating and unmating cycles without additional lubrication of the coupling devices. The connector mating faces may be cleaned after the 1000 cycles have been completed.

6.5 Salt Spray (Deleted)

6.6 Immersion

The immersion test, in which the specimens are totally immersed in water at a specified pressure, is intended to determine if the sealing provisions at the mating interface and cable entry are capable of excluding water from the interior portions of the connector.

6.6.1 References

Refer to paragraph 3.2.5.2.4 of "Technical Guidelines for Ultra Low Loss Optical Fiber Assemblies."

6.6.2 Test Equipment

The test equipment will consist of the following:

a. Water vessel capable of maintaining a pressure of 18 kPa

b. Optical power radio meter

c. Optical transmitter

d. Power supply

e. Pressure regulator with gage

6.6.3 Test Method

Install the completely mated connector sample inside the water container with the transmitter and detector ends of the fiber optic cable brought outside through suitable seals to withstand the test pressure. Connect the optical transmitter to a dc power source capable of supplying 300 mA at 12 to 15 V. Allow

sufficient time for the transmitter to warm up to operating temperature before proceeding with any optical measurements. Fill the water vessel with room temperature tap water to completely cover the mated connector pair. Seal the water vessel and pressurize it to 18 kPa (equivalent to 1.836 m head of water). Maintain this condition for a period of 24 h.

Initially, and periodically throughout the exposure, measure the CPR for each fiber in the connector. (These measurements are intended to verify continuity only and are not considered a formal coupling loss measurement.) At the conclusion of the exposure, and without disturbing the sample, perform a coupling loss measurement as described in paragraph 6.2.3.3.

Remove the specimen from the water vessel and carefully dry all exterior surfaces. Exercising care not to introduce any remaining exterior water to the inside of the connectors, unmate the sample and examine for the presence of water within the sealed area of the connectors.

6.6.4 Test Data

Immersion data sheets will contain sample identification, a description of the test setup, records of the CPR readings for continuity, the results of the coupling loss test, and observations of the condition of the sample at the end of the test,

including whether moisture has penetrated into the sealed area of the connector.

6.6.5 Requirements

The mated connectors will exclude water from the sealed interior portions when immersed in water to a depth of 1.83 m. The connectors will maintain continuity throughout the exposure and will meet the coupling loss requirement at the conclusion of the exposure.

6.7 Shock Drop (Deleted)

6.8 Sand and Dust (Deleted)

6.9 Cable Retention

The cable retention test is intended to determine whether the connector strain relief mechanism is capable of withstanding a static tensile load tending to pull the cable from the rear of the connector body without damage to either the connector or the cable within the strain relief.

6.9.1 References

Refer to paragraph 3.2.5.2.7 of "Technical Guidelines for Ultra Low Loss Optical Fiber Assemblies."

6.9.2 Test Equipment

The test equipment will include the following:

a. Tensile test apparatus

b. Receptacle mounting adapter for tensile tests

c. Optical cable mandrel (cylinder approximately 400 mm diameter by 200 mm high with cylindrical surface wrapped with double faced tape for good grip)

6.9.3 Test Method

Perform this test on both plug and receptacle connectors. Mount the receptacle on the mounting adapter plate with its jam nut. Install the optical cable mandrel on the uprights of the tensile test machine. Install the receptacle with its cable entry upward on the crosshead of the test machine. Wrap at least five turns of cable around the cable mandrel taking care that no excess slack is left between the connector and the mandrel. Leave at least a 160 mm separation between the rear of the connector and the first turn on the mandrel.

Activate the test machine crosshead and apply an increasing load between the connector and the test cable until a load of 1780 N has been applied. Maintain this load for a period of 60 s and then remove it. Observe the connector and cable during the loading for any evidence of damage or movement. Remove the receptacle from the test machine and carefully examine it.

Mate the receptacle with its counterpart plug connector and reinstall the mated pair on the crosshead of the test machine with the

plug cable entry upward. Wrap at least five turns of the plug cable around the cable mandrel and repeat the loading as described above for the receptacle.

6.9.4 Test Data

The data sheets for the cable retention test will contain the sample identification, a description of the test setup with a sketch or photograph of the significant details, and a record of the observations made during and after the loading.

6.9.5 Requirements

The plug and receptacle samples will withstand a tensile load of 1780 N for a period of 60 s without physical damage and will be capable of meeting the requirements of succeeding tests.

6.10 Flex Life

The flex life test is intended to determine the ability of the connector strain relief mechanism to protect the optical cable from flexing stresses such as might be imposed during handling of cables in field service.

6.10.1 References

Refer to paragraph 3.2.5.2.8 of "Technical Guidelines for Ultra Low Loss Optical Fiber Assemblies."

6.10.2 Test Equipment

The test equipment will include the following:

a. Flex life cycling apparatus
b. Optical power ratio meter
c. Optical transmitter
d. Power supply
e. High-low temperature chamber

6.10.3 Test Method

Figure 6.10.3-1 shows the fixture configuration that could be used for the flex life test. The pivot point (P) is a minimum distance (PE) from the end of the connector to preclude the cable from swinging. The distance L which defines the location of mass M is set at approximately 150 mm. The gravitational force exerted by mass M should cause the cable to become taut and hang vertically at point G in the neutral axis. A mass of approximately 1 kg is adequate to accomplish this.

This test consists of two parts -a room temperature phase and a low temperature phase. It may be more convenient to make the set-up in the temperature chamber and perform both parts without having to move the apparatus. Mount the flexing apparatus so that the flexing motion can be input to the test chamber through a test port in the chamber wall. Only the sample mounting plate and support bearing need be inside the test chamber. Adjust the limit

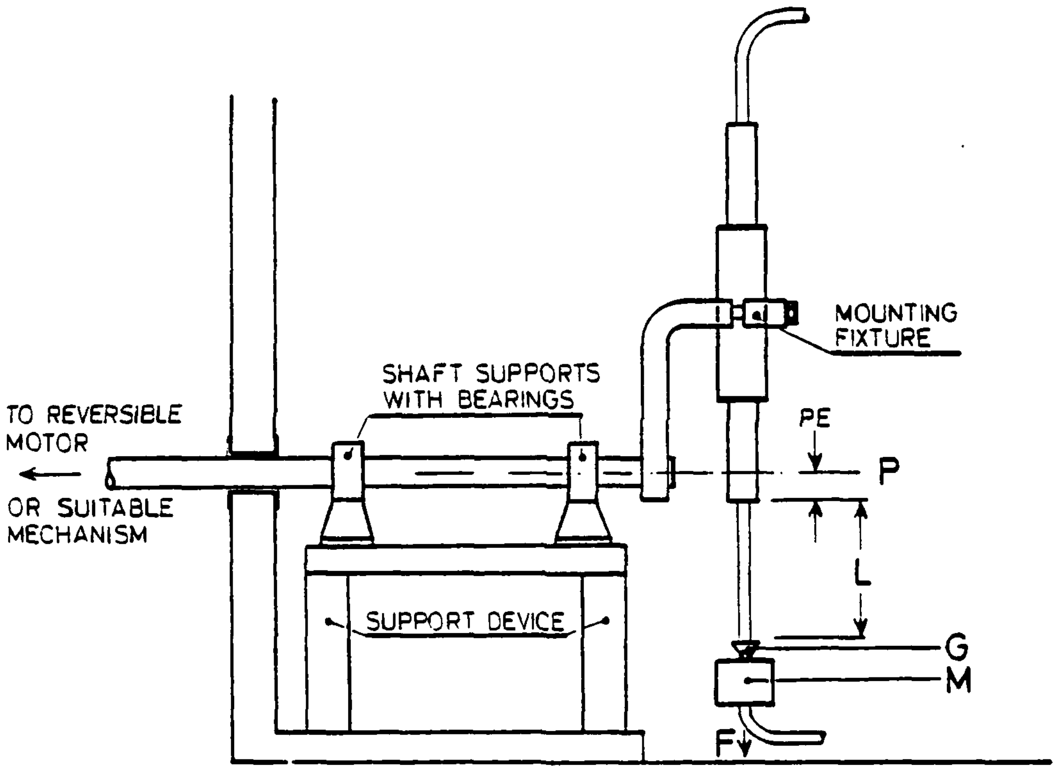

Figure 6.10.3-1. Fixture Configuration for Flex Life Test.

switches on the reversing motor to provide a flexing action 90° on either side on the neutral axis as shown in Figure 6.10.3-2. Mount the receptacle on the mounting fixture, cable entry upward, using the mounting jam nut. Couple the counterpart plug to the receptacle with the cable entry downward. Attach the stabilizing mass (M) to the plug cable 150 mm (L) below the rear of the plug. Use care to avoid damage to the cable jacket where the mass is attached. Route the optical cable outside the chamber through one of the test ports so that optical power ratio measurements can be made.

Connect the optical transmitter to a dc power source capable of supplying 300 mA at 12 to 15 V. Allow sufficient time for the transmitter to warm up to operating temperature before proceeding with any measurements. Record the CPR values for each fiber before starting the flex test.

With the sample exposed to laboratory ambient conditions, energize the flexing apparatus and subject the cable to 1000 flex cycles. Periodically throughout the exposure, monitor the CPR for each fiber in the test cable. (These measurements are intended to verify continuity only and are not considered a formal coupling loss measurement.)

At the conclusion of the 1000 flex cycles, deenergize the flexing apparatus and rotate the test sample 90° about its mating axis as

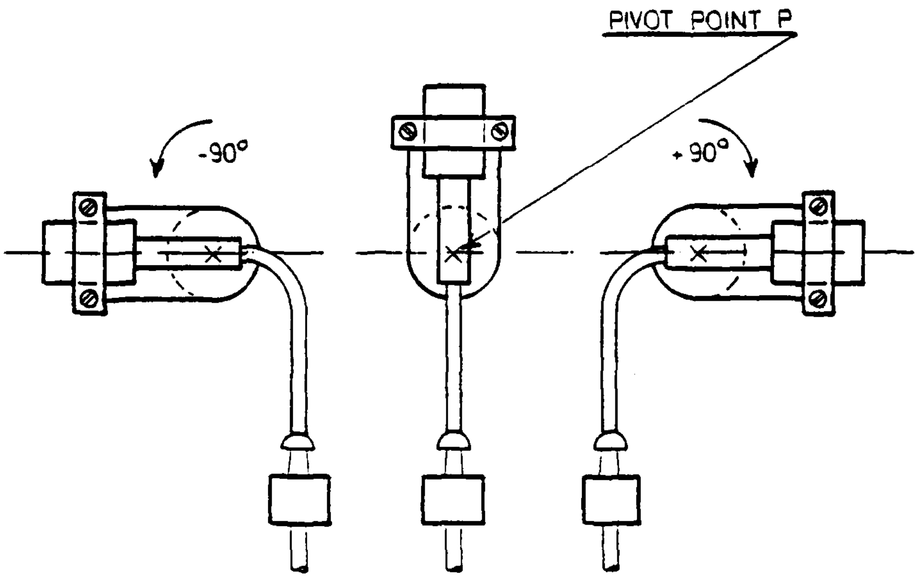

Figure 6.10.3-2. Fixture Configuration Flexing Action.

shown in Figure 6.10.3-3. Resume cycling with the connector in its new orientation until an additional 1000 flex cycles have been completed. Monitor CPR as before. This concludes the room temperature phase of the test. Inspect the cable carefully in the area protected by the connector strain relief for any evidence of deterioration.

Orient the flex fixture so that the connector is in the neutral (vertical) axis. Program the test chamber to control temperature at 70°C (±2°). Expose the connector to this condition for a period of at least 48 h.

Program the test chamber to control temperature at -55°C (±3°). Expose the connector to the low temperature condition for a period of at least 48 h. At the conclusion of the 48-h period and while the connector is still exposed to -55°, energize the flexing apparatus and subject the sample to 500 flex cycles. Monitor CPR initially and periodically throughout the exposure.

At the conclusion of the 500 flex cycles, deenergize the flexing apparatus and rotate the test sample 90° about its mating axis as shown in Figure 6.10.3-3. Use protective gloves and perform this operation as quickly as possible to avoid unnecessary heat input to the sample. Resume cycling with the connector in its new orientation until an additional 500 flex cycles at low temperature

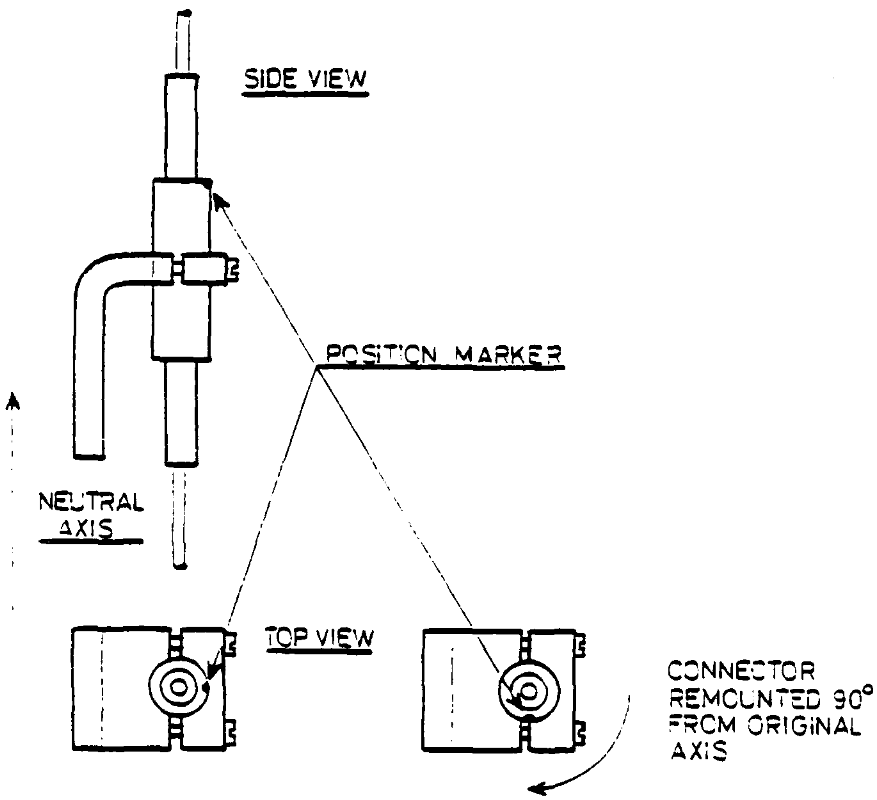

Figure 6.10.3-3. Flexing Apparatus Deenergized.

have been completed. Monitor CPR as before. This concludes the low temperature portion of the test. Remove the sample from the test chamber. Allow the temperature chamber to return to room temperature before removing the test sample. Perform a complete examination paying particular attention to the cable where it is protected by the connector strain relief.

6.10.4 Test Data

The data sheets for flex life will include sample identification, a description of the test setup including a sketch or photograph, records of the CPR values and when they were measured, and a complete description of the condition of the connector and cable at the conclusion of the test.

6.11 Twist

The twist test is intended to detrmine if the cable retaining feature at the rear of the connector is capable of withstanding torsional stresses such as might be applied by the cable during field handling without damage to either the connector or the fiber cable.

6.11.1 References

Refer to paragraph 3.2.5.2.9 of "Technical Guidelines for Ultra Low Loss Optical Fiber Assemblies."

6.11.2 Test Equipment

The test equipment will include the following

a. Motorized twist test apparatus
b. Optical power ratio meter
c. Optical transmitter
d. Power supply
e. Receptacle mounting plate

6.11.3 Test Method

Mount the receptacle to its mounting plate and secure the plate in a vise or other suitable clamping means. Couple the counterpart plug to the receptacle. Position the twist test apparatus so as to grip the fiber cable at a point 153 mm behind the rear of the plug cable retaining fixture. Before tightening the cable grip, program the twist apparatus to provide a twisting action as shown in Figure 6.11.3-1 ±90° about the cable neutral axis. One twist cycle is defined as passing from the neutral position to +90°, reversing back through neutral to -90°, and reversing back again to the neutral position, a total excursion of 180°.

With the twist apparatus in the neutral position, tighten the fiber cable clamp securely on the cable taking care not to damage the cable. Connect the optical transmitter to a dc power source capable of providing 300 mA at 12 to 15 V. Allow sufficient time for the transmitter to warm up to operating temperature before

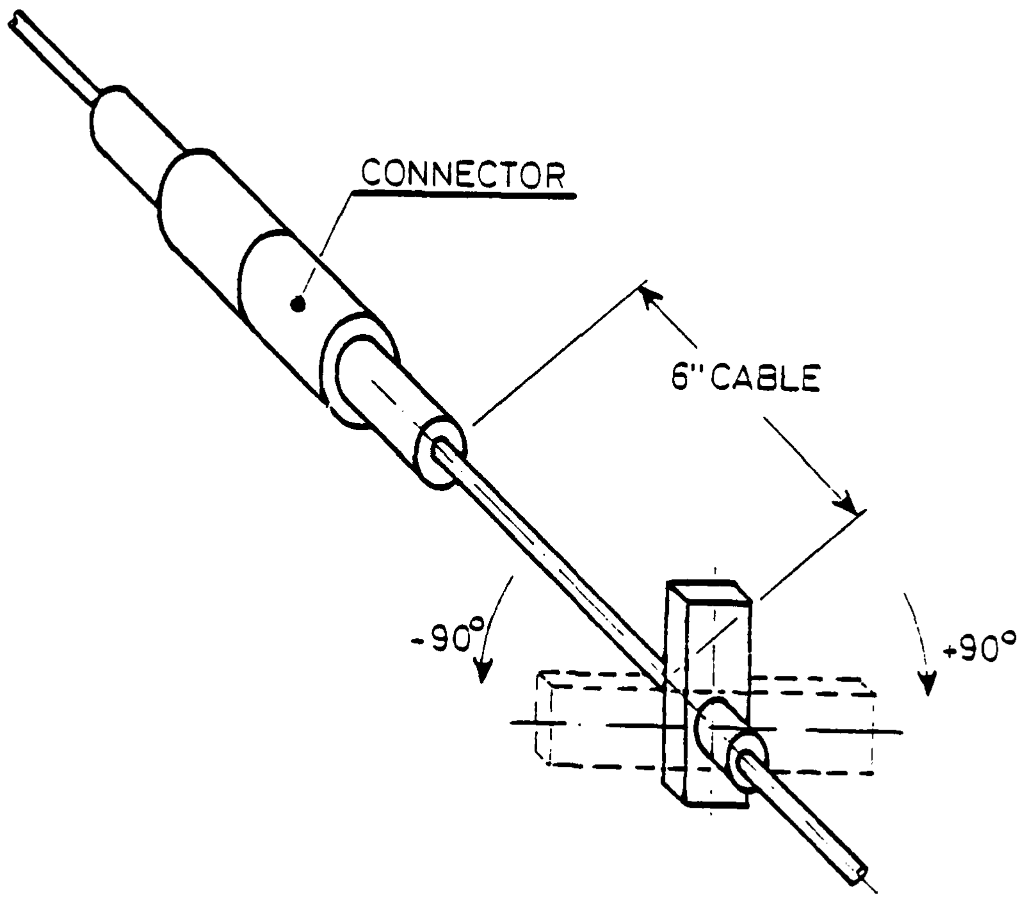

Figure 6.11.3-1. Cable During Twisting Action.

9 December 1978

ULTRA LOW LOSS OPTICAL FIBER
CABLE ASSEMBLIES
C001 CABLE, CONNECTORS, AND
CABLE ASSEMBLY TEST PLAN

Part 1: CABLE TEST PLAN

for

U. S. ARMY CORADCOM
Fort Monmouth, New Jersey

Contract #DAA B07-78-C-2922

Prepared by:

S. Mahurin

ITT ELECTRO-OPTICAL PRODUCTS DIVISION
P. O. Box 7065
Roanoke, Virginia 24019

Approved by: Michael F. Toohig
M. F. Toohig, Vice President
Director of Engineering

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1.0 SCOPE

1.1 Purpose

This test plan establishes the tests to be performed on the cable design samples (CLIN 0002) delivered under Contract Number DAA B07-78-C-2922. Included is information on the number of samples, the length of each sample, and the test procedure for each test.

2.0 TESTING SUMMARY

A summary of all tests to be performed, the number and length of samples required, the optical monitoring functions required, and the paragraph describing the test procedure is given in Table 2-1. All samples used in the testing program whose length is less than 300 m will be taken from a longer length which was subjected to the optical transmission tests of paragraph 3.0. Those tests requiring a 300m sample length will be performed in the order listed in Table 2-1 on the same sample.

Table 2-1 - CABLE TESTING SUMMARY

TEST	NUMBER OF SAMPLES (per design)	SAMPLE LENGTH	OPTICAL MONITORING CONTINUITY	DIFF. ATTN.	POST TEST ATTN	TEST PROCEDURE PARAGRAPH
Attenuation	All (1)	$\geq$300 m				3.1
Data Transmission	All (1)	$\geq$300 m				3.2
Numerical Aperture	All (1)	$\geq$300 m				3.3
Tensile Load	2	20 m		XXX		4.1
Mechanical Tests	36	90m (2)	XXX			4.2
Vibration	1	$\geq$300 m			XXX	4.3
Temperature Shock	1	$\geq$300 m			XXX	4.4
Humidity	1	$\geq$300 m			XXX	4.5
Fungus	2	0.5 m				4.6
Nuclear Survivability	2	~100 m (3)		XXX		4.7

(1) 100% Testing of all lengths $\geq$ 300 m

(2) Total length required for all 36 samples

(3) Exact length to be determined by test facility capability

3.0 TRANSMISSION TEST PROCEDURES

3.1 ATTENUATION

3.1.1 SPECIFICATION

a) Wavelengths: 8,200; 8,500; 10,600 Angstroms

b) Attenuation: 5 dB/km (maximum)

3.1.2 TEST DEFINITION

The optical attenuation of each cabled fiber will be measured at three selected wavelengths.

3.1.3 TEST EQUIPMENT AND PROCEDURE

The equipment of Figure 3-1 will be used to measure attenuation. The procedure will follow method 6020 of DOD-STD-1678. The output through the fiber is measured at each specified wavelengh with injection input numerical apertures of .089, .124, .176 and .243. Once the output through the long length is measured at the specified wavelengths, the fiber will be cut at a distance of 1 m from the injection end. A new end is prepared on the output end of the reference length and the measurement repeated for the short length.

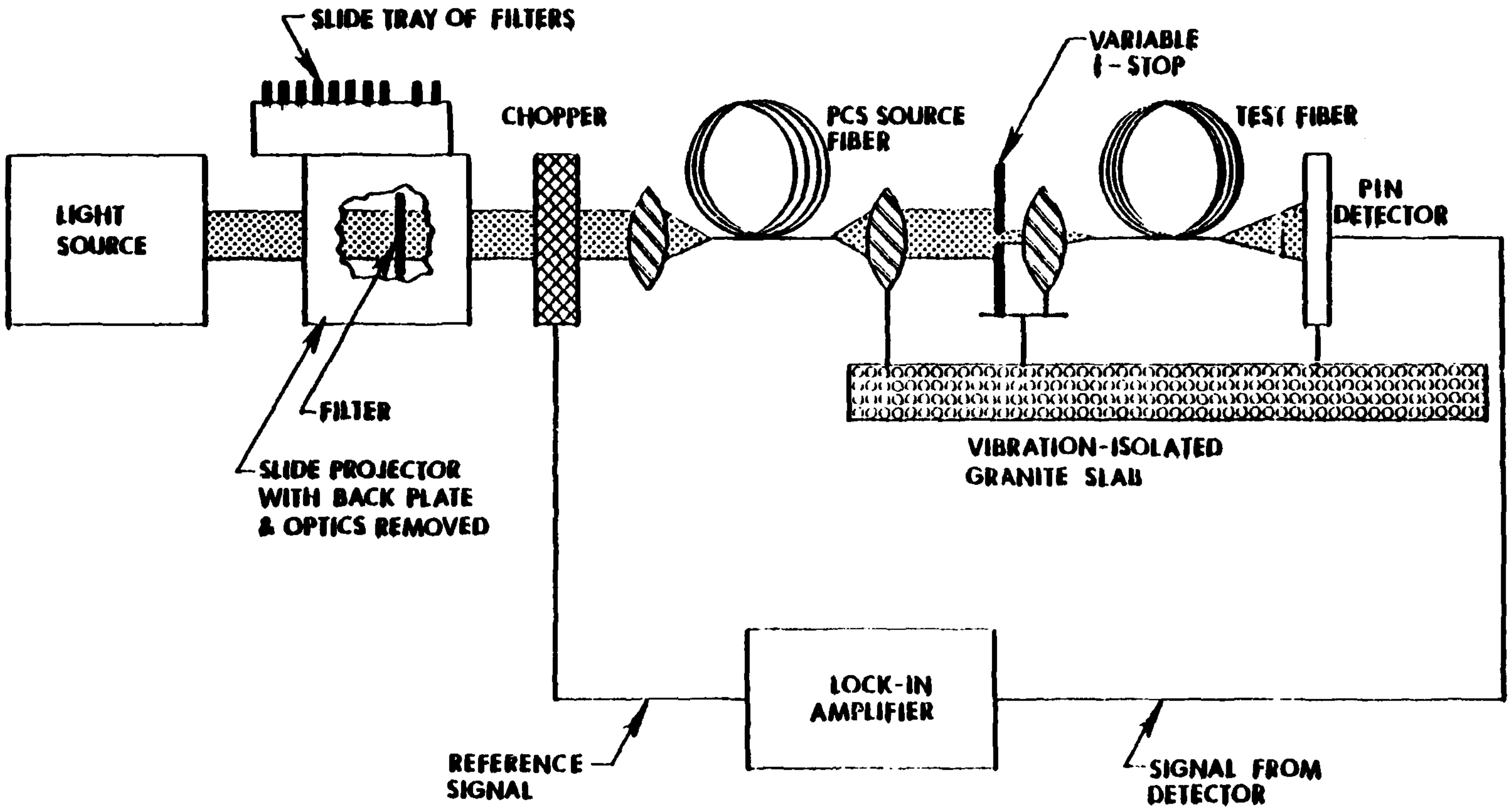

Figure 3-1

ATTENUATION MEASUREMENT STATION

302 10030

3.1.4 DATA REDUCTION

The attenuation at each wavelength and injection numerical aperture (N.A.) is calculated per the relation

$$\alpha\ (N.A., \lambda) = -10 \log \frac{V_L/V_R}{L_L - L_R} \quad dB/km$$

where V_L = output voltage detected through long length L_L

and V_R = output voltage detected through reference length L_R (L_R = 1 m)

3.1.5. TEST RESULTS REPORTING

The attenuation of each test fiber at all three wavelengths with an input N.A. of .089 will be reported.

3.1.6 TEST FACILITY AND PERSONNEL

ITT-EOPD measurement equipment and personnel will be used.

3.2. DATA TRANSMISSION

3.2.1 SPECIFICATION

Pulse dispersion 2 nsec/km maximum

3.2.2. TEST DEFINITION

The 50% (or 3dB) optical pulse dispersion of the test fiber will be measured at 9,000 Angstroms.

3.2.3 TEST EQUIPMENT AND PROCEDURE

The equipment of Figure 3-2 will be used to measure pulse dispersion. The substitutionary procedure of Method 6050 of DOD-STD-1678 will be utilized. The substitutionary reference pulse will be measured periodically using a one to ten meter length of graded index fiber similar to that used in the cables. A typical input pulse is shown in Figure 3-3.

During the procedure, one end of the fiber is positioned in the input beam to obtain maximum output with the laser pulsed just above threshold. The output waveform, detected by the PIN diode, is displayed on the sampling scope and a permanent record made with the X-Y recorder.

3.2.4. DATA REDUCTION

The dispersion of the fiber is calculated per the relation·

$$\lambda(50) = \frac{\left(W_L{}^2 - W_R{}^2\right)^{1/2}}{L_L - L_R} \text{ ns/km}$$

where λ (50) = pulse dispersion in ns/km measured at 50% of the maximum pulse amplitude.

W_L = pulse width at 50% maximum pulse amplitude of the long test fiber output waveform in ns.

W_R = pulse width at 50% maximum pulse amplitude of the reference test fiber output waveform in ns.

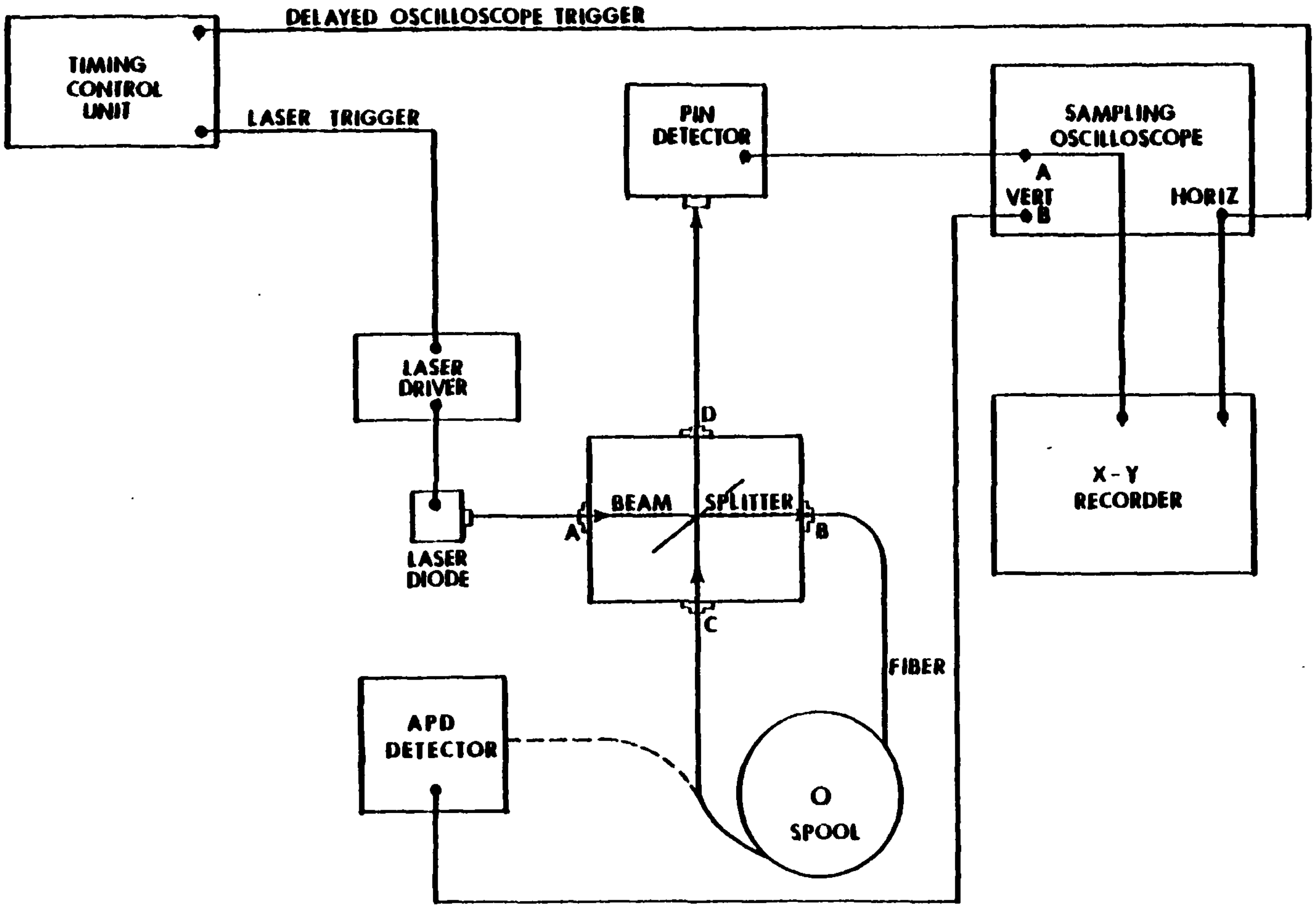

Figure 3-2

DISPERSION MEASUREMENT STATION

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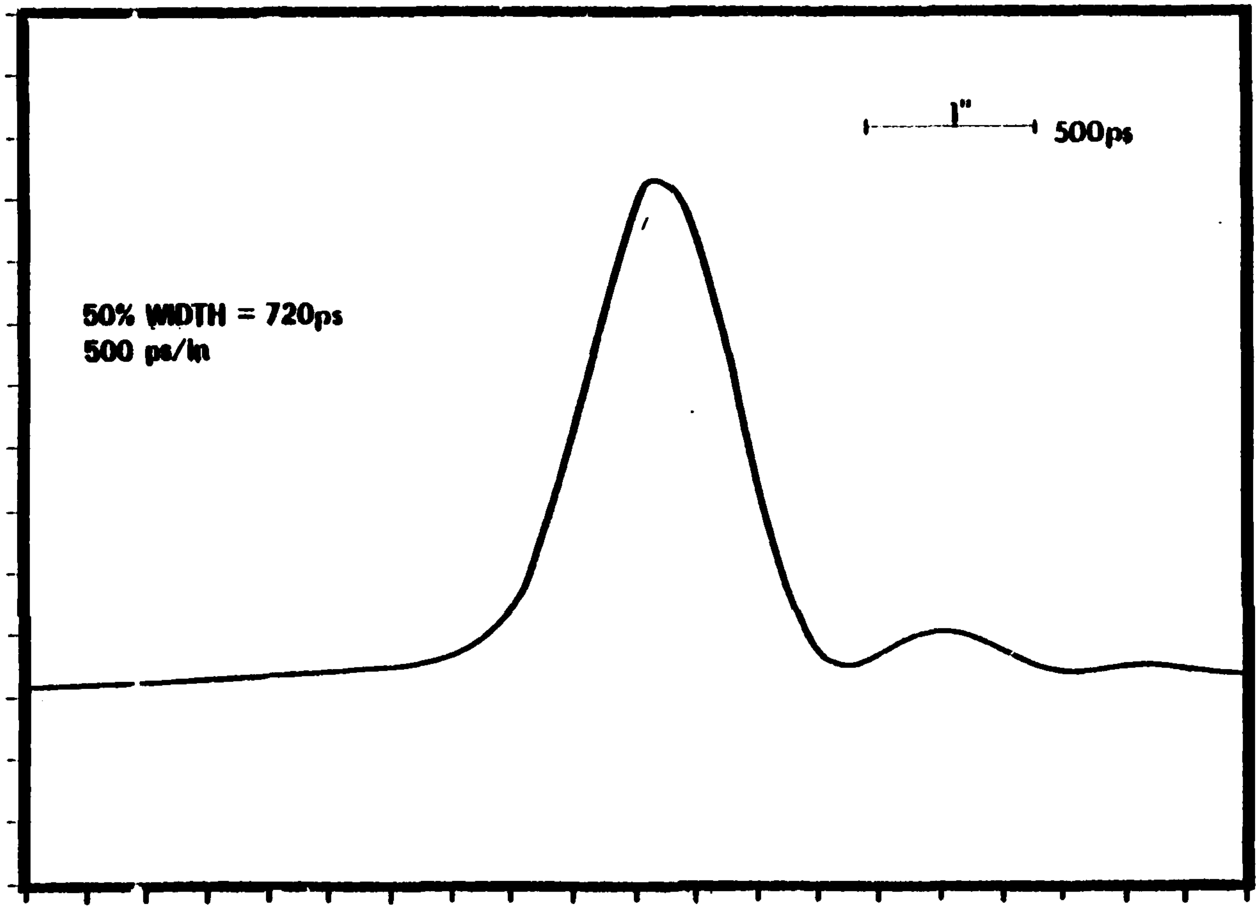


DISPERSION STATION INPUT PULSE WITH C30902E DETECTOR

Figure 3-3 302 10540

L_L = length of long test fiber in km.

L_R = length of reference test fiber in km.

The values of W_L and W_R are obtained graphically from the waveforms recorded on the X-Y recorder.

3.2.5 TEST RESULTS REPORTING

The 50% pulse dispersion of the test fiber shall be reported.

3.2.6 TEST FACILITIES AND PERSONNEL

ITT-EOPD measurement equipment and personnel will be used.

3.3. NUMERICAL APERTURE (N.A.)

3.3.1 SPECIFICATION

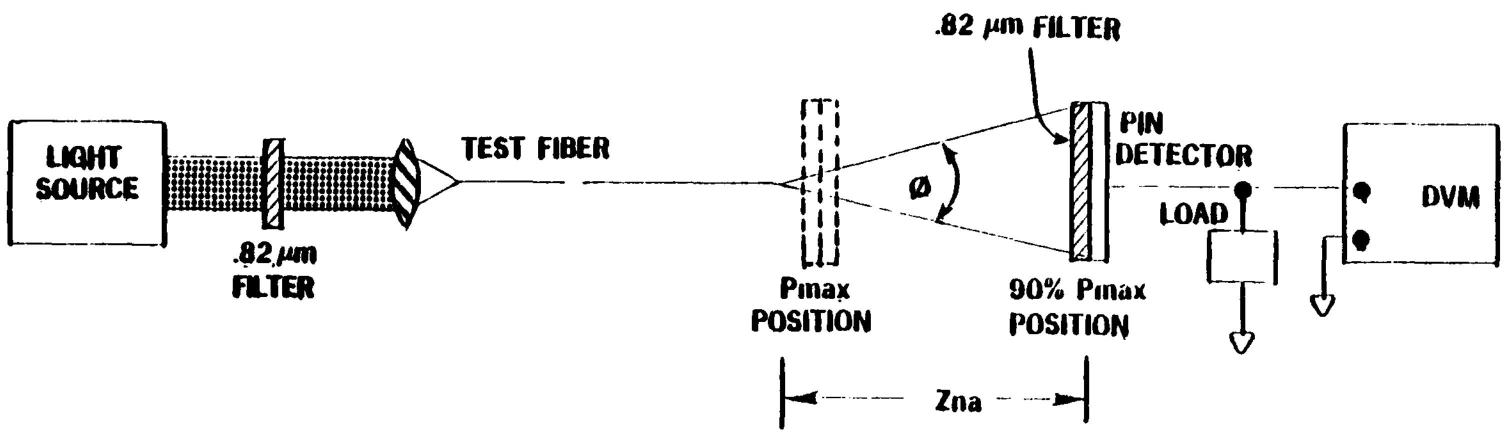
.14 minimum

3.3.2 DEFINITION OF TEST

The exit N.A., defined as sin ϕ, where ϕ is the cone angle containing 90% of the output power, of each cabled fiber will be measured.

3.3.3 TEST EQUIPMENT AND PROCEDURE

The equipment of Figure 3-4 will be used. First, ends are made at both fiber ends by the scribe and break technique.



N.A. MEASUREMENT STATION

Figure 3-4

302 10:11

Mode stripping compound is applied near each end. The output end is positioned in the P_{max} position of Figure 1.3, perpendicular to and centered on the detector surface. The input end is then positioned in the .336 N.A. source beam for maximum output. The detector is then moved away from the output end to a position corresponding to an N.A. of 0.14. The output end is then positioned for maximum output to insure proper alignment to the detector surface. The detector is then returned to the P_{max} position, and P_{max} is recorded.

The detector is then moved away from the output end until the output level drops 10% from the P_{max} value. At this time the separation z_{NA} between the fiber output end and the detector surface is measured and recorded.

3.3.4 DATA REDUCTION

The exit N.A. is calculated from the relation

$$N.A. = \frac{r_d}{(r_d^2 + z_{N.A.}^2)^{1/2}}$$

where r_d = radius of large area detector in mm.

and z_{NA} = measured distance between the fiber output end and the detector surface at 90% output power level in mm.

3.3.5 TEST RESULTS REPORTING

The N.A. of the test fiber will be reported.

3.3.6 TEST FACILITY AND PERSONNEL

ITT-EOPD measurement equipment and personnel will be used.

4.0 MECHANICAL AND ENVIRONMENTAL TEST PROCEDURES

4.1 TENSILE LOAD

4.1.1 SPECIFICATION

Gage Length	6 m
Load	181.44 kg for 1 mimute
Post load attenuation	$\alpha \leq 5$dB/km
Visual	No damage or degradation

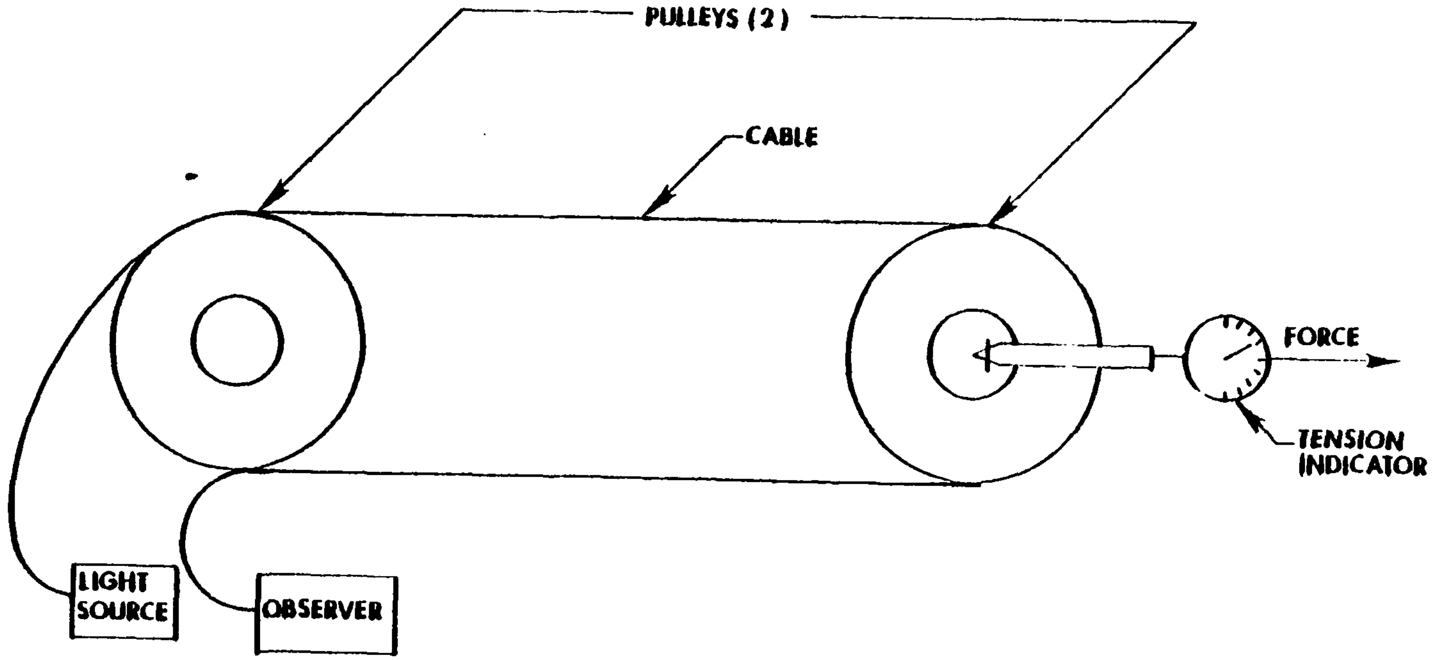
4.1.2 TEST DEFINITION

A six meter gage length of cable is subjected to a tensile load of 181.44 kg for a period of one minute. The attenuation of the cabled fibers is monitored during the entire test.

For additional data on long term effects the static load is then reapplied for a period of 48 hours during which the transmission through the fibers is monitored.

4 1.3 TEST EQUIPMENT AND PROCEDURE

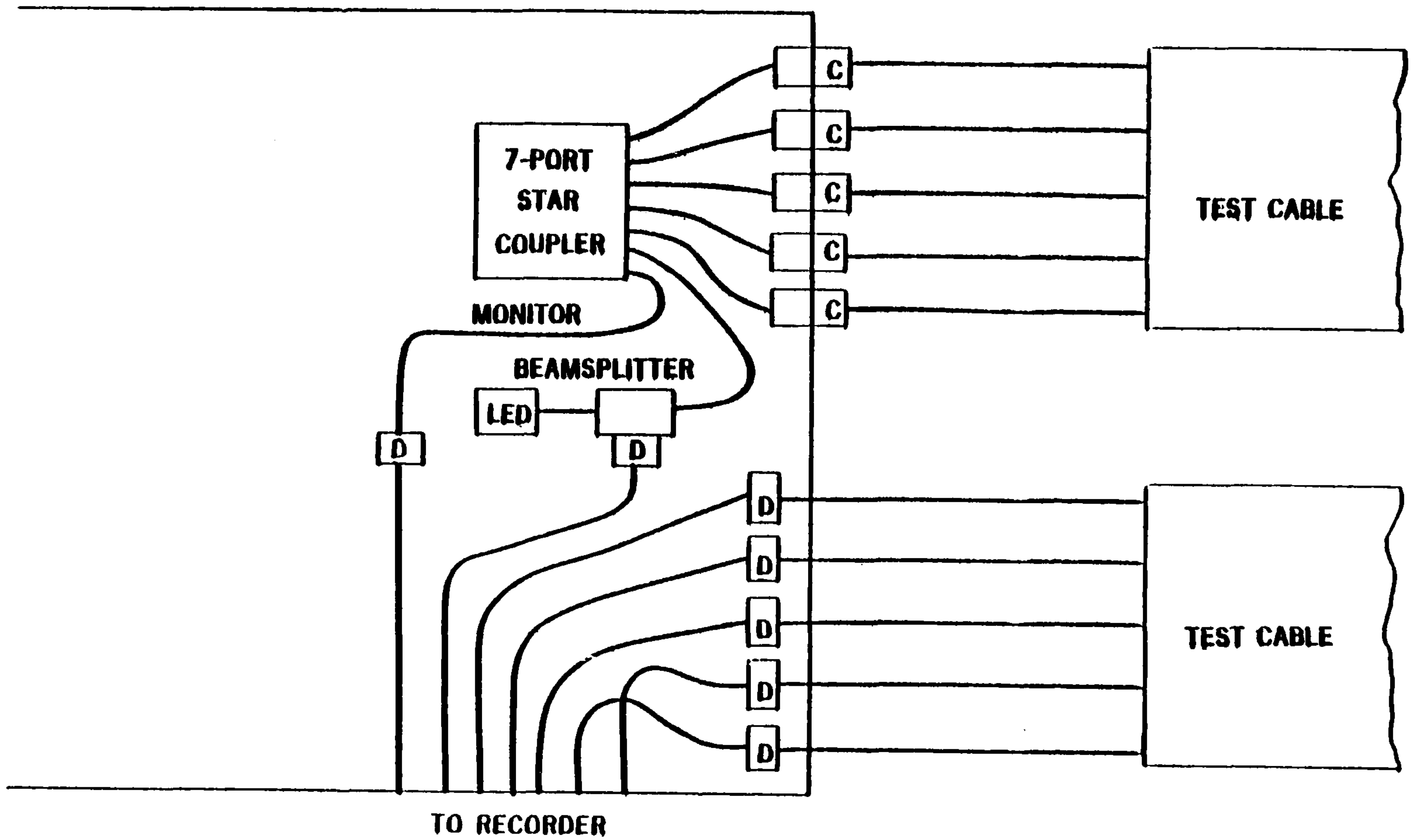
The equipment of Figures 4-1 and 4-2 will be used, respectively, to apply the tensile load and monitor any changes in transmission during the test. The cable, wound on a suitable reel, is prepared for the test by mounting connectors on the inner end of the cable and stripping the jacket from 1 m at the outer



STATIC SHORT-LENGTH CABLE STRENGTH TESTER

Figure 4-1

302 10944



ATTENUATION MONITORING SYSTEM

302 10945

Figure 4-2

16

end of the cable. The outer end of the cable is then positioned in the apparatus of Figure 4-1. Approximately 10 m of the cable end is left free to prevent jacket slippage at the termination pulley. Ends are prepared on the fiber at the other end and the fibers placed in the output coupling fixture of the monitor unit of Figure 4-2. The connectors are then joined to the bulkhead connectors on the monitor unit. Initial values are recorded of the detector voltages of the monitor and output detectors and the chart recorder turned on. The load is applied for one minute. The load is applied and removed as quickly as reasonable but not instantaneously. The time the load is obtained and removed will be noted for correlation with stripchart data. Following the removal of the load, the cable is allowed to recover at a nominal tension for a minimum period of 30 minutes. The load is then reapplied and the monitor and output detector voltages measured either periodically or continuously for a period of 48 hours.

4.1.4 DATA REDUCTION

Differential attenuation is calculated for each fiber at test points of interest per the relation.

$$\Delta \alpha = 10 \log \frac{V_t}{V_i} - 10 \log \frac{V_{to}}{V_{io}}$$

where V_t = voltage at monitor detector at time of measurement

V_i = voltage at output fiber detector i (i=1, 2,.....6) at time of measurement

V_{to} = voltage at monitor detector at beginning of test

and V_{io} = voltage at output fiber detector i at beginning of test

Points of interest shall be initial and final values, minimum and maximum deviations plus any points of significant change.

4.1.5 TEST RESULTS REPORTING

A graph of differential attenuation as a function of time and tensile load will be provided for each sample tested.

4.1.6 TEST FACILITY AND PERSONNEL

ITT-EOPD measurement equipment and personnel will be used. Rental of a multipen stripchart recorder may be required.

4.2. MECHANICAL TESTS

4.2.1 SPECIFICATIONS

Impact	200 impacts at .415 kg-m (objective) limit to be determined
Bend	2000 cycles (specification) limit to be determined (4000 cycles maximum)
Twist	2000 cycles (specification) limit to be determined (4000 cycles maximum)

4.2.2 TEST DEFINITION

Cable samples will be subjected to Impact, Twist and Bend testing per paragraph 4.5.4.1 of MIL-C-13777F at ambient temperatures of 68 to 95° F, 160°F, and -65°F.

4.2.3 TEST EQUIPMENT AND PROCEDURE

Per paragraph 4.5.4.1 of MIL-C-13777F except that optical continuity of the fibers shall be monitored where electrical continuity is required. Optical continuity will be monitored by illuminating one end of the fiber with a standard microscope illuminator and recording the output level with a photodetector and stripchart recorder.

4.2.4 TEST RESULTS REPORTING

The level of mechanical stress and the number of cycles preceding any fiber breakage shall be reported for each test and test sample.

4.2.5 TEST FACILITY AND PERSONNEL

Test facility not yet determined. ITT-EOPD personnel will assist in performing the tests at test facility.

4.3 VIBRATION

4.3.1 SPECIFICATIONS

Vibration Environment	per curve W Figure 14.2-6, M1L-STD 810C
Sweeps	3 parallel to sample axis 3 orthogonal to sample axis
Sweep Time	15 minutes
Past Test Cable Properties	Attenuation <5.0 dB/km at specified wavelengths (per paragraph 3.1)

4.3.2 TEST DEFINITION

A full length test sample (≥ 300 m) wound on a suitable reel is subjected to vibration testing along two axes per method 514.2 procedure VIII of M1L-STD-810C. Following the test, the optical attenuation of the sample is measured per paragraph 3.1.

4.3.3. TEST EQUIPMENT AND PROCEDURE

The equipment and procedure to be used will follow method 514.2, Procedure VIII of M1L-STD-810C. A sample greater than 300m in length wound on a suitable reel will be secured to a suitable vibration table with the motion axis parallel to the reel axis. The sample is then vibrated per curve W of Figure 514.2-6 of M1L-STD-810C for three 15 minute sweep cicles. The sample is then rotated and secured on the vibration table so that the motion axis is perpendicular to the reel

axis and the sweep cycles repeated.

Following the vibration testing the attenuation of the sample cable is measured per the procedures and requirements of paragraph 3.1.

4.3.4 DATA REDUCTION

The attenuation of each cabled fiber is calculated per Section 3.1.4.

4.3.5 TEST RESULTS REPORTING

The pre test and post test attenuation of each cabled fiber will be reported.

4.3.6 TEST FACILITY AND PERSONNEL

ITT-EOPD measurements personnel and equipment will be used.

4.4 TEMPERATURE SHOCK

4.4.1 SPECIFICATION

Test Conditions:	per Method 503.1 of MIL-STD-810C
Post Test Performance:	attenuation <5.0dB/km at specified wavelengths per paragraph 3.1

4.4.2 TEST DEFINITION

Test cables in lengths greater than 300 m are subjected to sudden ambient temperature changes to determine the permanent effect of such environmental factors on cable attenuation.

4.4.3 TEST EQUIPMENT AND PROCEDURE

The equipment and procedure described in Method 503.1, Procedure I, MIL-STD-810C will be used. Following the final cycle at room temperature, the attenuation of the cabled fibers is measured per the procedure and requirements of paragraph 3.1.

4.4.4. DATA REDUCTION

The attenuation of each cabled fiber is calculated per paragraph 3.1.4.

4.4.5 TEST RESULTS REPORTING

The pre test and post test attenuation of each cabled fiber will be reported.

4.4.6 TEST FACILITY AND PERSONNEL

ITT-EOPD measurement equipment and personnel will be used.

4.5 HUMIDITY

4.5.1 SPECIFICATION

Test Conditions	per Method 507.1 Procedure II, MIL-STD-810C, deleting measurements during test.
Post Test Performance	attenuation <5.0 dB/km at specified wavelengths per paragraph 3.1

4.5.2 TEST DEFINITION

A test cable whose length is a minimum of 300 m will be subjected to temperature cycling at high ambient humidity to determine what effect warm, humid environments have on cable attenuation.

4.5.3 TEST EQUIPMENT AND PROCEDURE

The equipment and procedure to be used is described in Method 507.1, Procedure II of MIL-STD-810C with the exception that the in test measurements are deleted. Following the test, the attenuation of the cabled fibers is measured per the procedures and requirements of Paragraph 1.1.

4.5.4 DATA REDUCTION

The attenuation of each cable fiber is calculated per Paragraph 3.1.4.

4.5.5. TEST RESULTS REPORTING

The attenuation of the cabled fibers before and after humidity

testing will be reported.

4.5.6 TEST FACILITY AND PERSONNEL

ITT-EOPD measurement equipment and personnel will be used.

4.6. FUNGUS

4.6.1 SPECIFICATIONS

Test Conditions	per Method 508 of MIL-STD-810C, controls required to show profuse growth over 50% of the area after 14th and 28th days of test.
Sample	[illegible] each per cable type, 50 cm long
Post Test Performance	No visible growth of fungus on test samples except sparse and tuberal development of the fungus spore and no more than two unrelated minute colonies.

4.6.2 TEST DEFINITION

Cable samples are exposed to fungi in an environment conducive to fungus growth to determine the resistance of the cable to fungal growth.

4.6.3 TEST EQUIPMENT AND PROCEDURE

The equipment and procedure to be used is described in Method

508.1 of MIL-STD 810C. As certain cleansing agents are known to inhibit the growth of fungus, the sample will be cleaned a minimum of one hour prior to starting the test to allow total evaporation of the cleansing agent.

4.6.4 TEST RESULTS REPORTING

Descriptions of the control and test samples at prescribed inspection internals and following test completion will be included in the testing laboratory's report.

4.6.5 TEST FACILITY AND PERSONNEL

Tests will be conducted by Aerospace Research Corporation of Roanoke, Virginia.

4.7 NUCLEAR SURVIVABILITY

4.7.1 SPECIFICATIONS

A)	Exposure	gamma radiation - 10^3 - 10^5 Roentgens (Cobalt 60) Neutrons - 10^{12} - 10^{14} /cm^2 (1 MeV equivalent)
B)	Time of Exposure	<10 second
C)	Cable Survivability	efforts to be determined

AD-A132 008 ULTRA LOW LOSS OPTICAL FIBER CABLE ASSEMBLIES VOLUME 2 (U) ITT ELECTRO-OPTICAL PRODUCTS DIV ROANOKE VA C HAND 07 JUN 83 ITT-80-22-07-VOL-2 CECOM/DRSEL-TR-78-2922F-2

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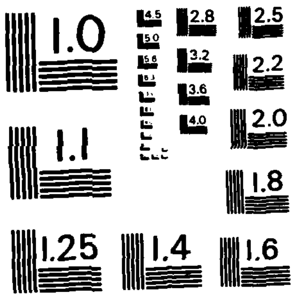

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

4.7.2 DEFINITION OF TEST

Portions of a cable sample will be exposed to the radiation levels described above. Differential attenuation of the cabled fibers will be monitored during exposure and for a period following exposure to determine the effect on attenuation.

4.7.3 TEST EQUIPMENT AND PROCEDURE

The cable sample will be connectored for use with the monitoring equipment of Figure 4-2. The length of the test cable that is exposed to the radiation will be determined by the test chamber capability of the test laboratory. Two laboratories are being considered as test facilities at this time: U. S. Naval Research Laboratory in Washington, D. C. and Harry Diamond Laboratory, in Adelphi, Maryland. The test specimen will be sufficiently long (100 m) to permit use of the monitoring equipment of Figure 4-2.

The output of the cabled fibers will be monitored before, during and following radiation exposure to determine the effects on the attenuation of cabled fibers.

4.7.4 DATA REDUCTION

The differential attenuation of each cabled fiber will be determined per Paragraph 4.1.4.

4.7.5 TEST RESULTS REPORTING

The differential attenuation of each cabled fiber during the test will be reported.

4.7.6 TEST FACILITY AND PERSONNEL

Test facility not yet determined. ITT-EOPD personnel will assist test facility personnel in conducting the test. Rental of a multi-pen stripchart recorder may be required.

APPENDIX B

QUALIFICATION TEST REPORT

FOR ULTRA LOW LOSS

FIBER OPTIC CABLE ASSEMBLIES

QUALIFICATION TEST REPORT

FOR

ULTRA LOW LOSS

FIBER OPTIC CABLE ASSEMBLIES

CONTRACT DAAB07-78C-2922

ITT PROJECT 36027

HUGHES AIRCRAFT COMPANY
CONNECTING DEVICES DIVISION
17150 Von Karman Avenue
Irvine, CA 92714

PREPARED BY:

Reliability Test Laboratory
Connecting Devices Division
Hughes Aircraft Company
Irvine, California 92714

QUALIFICATION TEST REPORT

FOR

ULTRA LOW LOSS

FIBER OPTIC CABLE ASSEMBLIES

ITT Project 36027

HUGHES AIRCRAFT COMPANY
CONNECTING DEVICES DIVISION
17150 Von Karman Avenue
Irvine, California 92714

PREPARED BY: D. R. Nagle DATE: 7-23-82

APPROVED BY: G M Badasch DATE: 7-23-82
G. M. Badasch, Manager
Reliability Test Laboratory

APPROVED BY: A. C. Villere DATE: 7-23-82
A. C. Villere, Manager
Reliability and Quality
Assurance

APPROVED BY: Mike Orr DATE: 7-27-82
Mike Orr, Fiber Optic
Project Engineer

APPROVED BY: C. Quella DATE: 7-23-82
C. Quella, Assistant
Division Manager

APPROVED BY: ______ DATE: ______
ITT - EOPD

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ADMINISTRATIVE DATA

PURPOSE OF TEST:	Qualification
MANUFACTURER:	Hughes Aircraft Company Connecting Devices Division 17150 Von Karman Avenue Irvine, California 92714
MANUFACTURERS TYPE OR MODEL NUMBER:	1143820S Plug 1127132-1S Receptacle 1093201-051F400S Pin 1093202-051F400S Socket #80581001 ITT Ultra Low Loss Cable
CUSTOMER PART NUMBER:	
DRAWING SPECIFICATION OR EXHIBIT:	ITT Project Test Plan Dated April 3, 1981
QUANTITY OF ITEMS TESTED:	6
SECURITY CLASSIFICATION OF ITEMS:	Unclassified
DATE TEST COMPLETED:	July 23, 1982
TEST CONDUCTED BY:	Reliability Test Laboratory Hughes, Irvine
DISPOSITION OF SAMPLES:	ITT Electro-Optical Products Division 7635 Plantation Road, N.W. Roanoke, Virginia 24019

ABSTRACT: PROBLEMS AND DISCUSSION

In performing the Immersion Test (Para. 6.6 Ultra Low Loss Connector Test Plan) on sample numbers 1 and 3, insertion losses in excess of the specification limit (2.0 dB) were observed. The samples were then disassembled to establish the reasons for these failures.

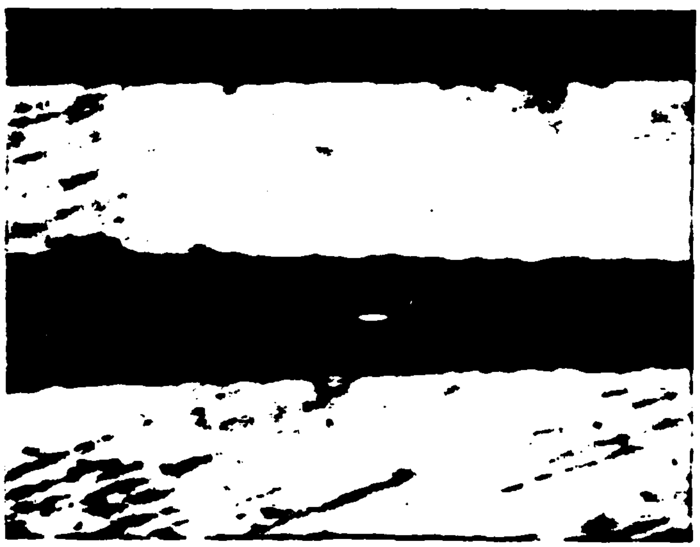
During this examination it was found that the samples displayed signs of corrosion. This was due to using a test chamber that had been previously used for a salt water immersion test. This chamber was improperly cleaned before the Immersion Test and was therefore contaminated with salt crystals. Also, the disassembly of the connector revealed torn o-rings inside the connector body as well as the strain relief housing. This was the result of missing a step (lubrication) in the connector assembly procedure.

The disassembled connectors were then cleaned with distilled water. The damaged internal o-rings were replaced and the connectors were reassembled. The samples were then remated and insertion loss measurements were taken. The initial measurements revealed no losses in excess of 2.0 dB. The samples were then placed in a new immersion chamber and the Immersion Test was reconducted. This second test resulted in failures, just as the first.

A new sample was prepared in order to determine the leakage paths for the immersion failures. After a thorough analysis, it was shown that the o-rings when properly installed do not leak. The sample was subjected to pressures up to 45 PSI. The leakage path was found to have been the thread area of the protective tube and receptacle shell. It should be pointed out at this time that the receptacle was not designed for this type of environment; i.e., the protective tube is inside the bulkhead. However, if this environment is required of the receptacle connector, provisions can be made.

Minor difficulty was experienced when failure occured at four service contacts. Two fibers cracked at the rear of the single channel connectors by jolts during transportation of the test station. The other two failures were due to improper epoxy filling of the service contacts. See accompanying pictures.

Correction was accomplished by removing the discrepancy from each fiber and reterminating the fiber with a new contact. Data was adjusted accordingly to compensate for any differences that the new termination caused.



```
990: MA 6 01 09:40 PDT 07/05/82
4^Z^Z MA 6 ^ZHUGHES IRVINE, CA 09:40 PDT 07/05/82
/TLX 829458 ITT EOPD ROA
/ATTN: MR. D. C. MINOR
/?9530?
/^Z^B
/Y//////
06 JUL/82 CW
MSG 7-3369-82
```

TO: ITT EOPD
ROANOKE, VA

ATTN: MR. D. C. MINOR
CC: KRAFT ELECTRONIC SALES, TOWSON, MD

REF: P.O. 34279

SUBJ: QUALIFICATION TEST

CONFIRMING OUR DISCUSSION WITH CHUCK HAND ON 7/1/82, 2 EA OF THE CONNECTOR/CABLE SAMPLES SUBJECTED TO THE IMMUSION TEST HAVE DEMONSTRATED INSERTION LOSS READINGS BEYOND SPECIFICATION LIMITS. PRELIMINARY FAILURE ANALYSIS INDICATES THAT THE WATER IS ENTERING THE CONNECTOR THROUGH THE REAR PORTION OF THE BULKHEAD CONNECTOR. PER YOUR DIRECTION HUGHES WILL CONTINUE WITH ANALYSIS TO PIN POINT THE AREAS OF LEAKAGE IN THE BULKHEAD AND INSURE THE PROPER FUNCTIONING OF THE PLUG CONNECTORS SEALS. QUALIFICATION TESTING FOR ALL SAMPLES WILL RESUME 7/6.

REGARDS,
TERRY JARNIGAN
HUGHES AIRCRAFT COMPANY
CONNECTING DEVICES DIVISION

```
^F^E^Z^C
/^Z^Z 7 ^ZHUGHES IRVINE, CA 09:41 PDT 07/05/82
/TWX 7102329351 KRAFT SLS TWSN
/ATTN:
/?9530?
/^Z^B
/^Z^C^Z^D
** BYE **
 connect 10 secs  listed 09:47 PDT 07/05/82
```

Q9Q: MA 26 Q1 16:26 PDT 07/06/82
4^Z^Z MA 26 ^ZHUGHES IRVINE, CA 16:26 PDT 07/06/82
/TLX 829458 ITT EOPD ROA
/ATTN: MR. D. C. MINOR
/?9530?
/^Z^B
/Y//////
06 JUL/82 CW
MSG 7-3380-82

TO: ITT EOPD
ROANOKE, VA

ATTN: MR. D. C. MINOR
CC: KRAFT ELECTRONIC SALES, TOWSON, MD

REF: HUGHES MSG #7-3369-82

SUBJ: QUAL TEST

HUGHES RELIABILITY TEST LAB PROCEDURES REQUIRES WRITTEN AUTHORIZATION TO CONTINUE INTO THE NEXT TEXT. PLEASE ACKNOWLEDGE THE ABOVE REFERENCED MESSAGE BY RETURN TWX.

REGARDS,
TERRY JARNIGAN
HUGHES AIRCRAFT COMPANY
CONNECTING DEVICES DIVISION

TWX 910-595-2523

^E^E^Z^C
/^Z^Z 27 ^ZHUGHES IRVINE, CA 16:26 PDT 07/06/82
/TWX 7102329351 KRAFT SLS TWSN
/ATTN:
/?9530?
/^Z^B
/^Z^C^Z^D
** BYE **
connect 6 secs listed 16:32 PDT 07/06/82

STARTING Unit 2
Page 80 Message #52
RX TWX:*
HACCONN IRIN

HACCONN IRIN

ITT EOPD ~~ROA~~
TO T JARNIGAN HUGHES AIRCRAFT CO IRVINE CA
FROM D C MINOR ITT EOPD ROANOKE VA
DATE JULY 7 1982
MSG 3057-82

REF A EOPD ORDER 34279
B HUGHES MSG 7-3369-82 AND 7-3380-82

EOPD CONFIRMS TELECON INSTRUCTION TO CONTINUE QUAL TESTING. WRITTEN REPORT TO ADVISE LEAKAGE POINT FOUND IN BULKHEAD.

REGARDS

MINOR
MCK
NNNN

HACCONN IRIN

ITT EOPD ROA
Page 84 IS HIGHEST

Page 84 IS NEXT
time 070611 DISCONNECT
connect 92 secs listed 06:11 PDT 07/07/82

P.O. ~~47665~~
ROANOKE, VA. 24019

3456

SHOW THE COMPLETE P.O. NO. ON ALL SHIPPING CONTAINERS, PACKING LISTS AND INVOICES

34279

21-Jul-81

HUGHES AIRCRAFT
CONNECTING DEVICES DIVISION
17150 VON KARMAN AVENUE
IRVINE, CA 92714

PLEASE FURNISH THIS COMPANY WITH THE ITEMS SPECIFIED BELOW SUBJECT TO THE CONDITIONS ON THE FACE HEREOF AND ON ATTACHED ITTEOPD FORM P001, "CONDITIONS OF PURCHASE." ACCEPTANCE BY SELLER IS LIMITED TO THE EXACT TERMS OF THIS PURCHASE ORDER.

20-Jul-81 JARNIGAN S.P. DAAB07-78-C-2922 DO-A7

UPS BLUE NET 30 15530 0 0 X

	ORDER QUANTITY		
1	1	LO	QUALIFICATION TEST AND REPORT PER INSTRUCTIONS IN REMARKS — 19-Nov-81 — 31415.0000 — 31415.00

REMARKS:
QUALIFICATION TEST AND REPORT PERFORMED IN ACCORDANCE WITH DOC I.D. NO. 81-12-10 EXCEPT FOR PARAGRAPHS 6.2.5, 6.4.5, 6.11 AND 6.12.
PARAGRAPH 6.2.5 'REQUIREMENTS': MATING TEST TO BE PERFORMED FOR DATA GATHERING PURPOSES. IT IS RECOMMENDED THAT MATING SHOULD CONTINUE WITHOUT CLEANING UNTIL THE AVERAGE ATTENUATION INCREASES BY 2DB. AS SOON AS 2DB IS REACHED, RECORD THE NUMBER OF CYCLES, CLEAN CONNECTOR, RECORD LOSS AFTER CLEANING, AND CONTINUE THE TEST. COMPLETE

CONFIRMATION OF PHONE ORDER

'81 JUL 28 AM 8 33

31415.

VIRGINIA STATE SALES TAX
TAXABLE
DO NOT BILL TAX
USE NO. 180060008 3

ITT ELECTRO-OPTICAL PRODUCTS DIVISION
BY BUYER

SELLER BY MAKING DELIVERIES UNDER THIS PURCHASE ORDER CERTIFIES THAT ALL SUPPLIES HAVE BEEN ... WITH THE DRAWINGS ... OTHER REQUIREMENTS FORMING A PART OF THIS PURCHASE ORDER. THE SELLER ALSO CERTIFIES THAT APPLICABLE INSPECTION ... MADE AVAILABLE FOR REVIEW BY AUTHORIZED ITT REPRESENTATIVES ON REQUEST

NOTICE TO SUBCONTRACTORS OF REQUIREMENT FOR CERTIFICATIONS OF NONSEGREGATED FACILITIES ... MAR 1968 ... 1001)

* NOTE: IF VENDOR PROMISED DELIVERY DATES SHOWN ABOVE CANNOT BE MET NOTIFY BUYER IMMEDIATELY

ORIGINAL PURCHASE ORDER

B-12

PAGE No. 8

International Telephone and Telegraph Corporation
Electro-Optical Products Division

3456

SHOW THE COMPLETE P. O. NO. ON ALL SHIPPING CONTAINERS, PACKING LISTS AND INVOICES

2
34279

21-Jul-

HUGHES AIRCRAFT
CONNECTING DEVICES DIVISION
17150 VON KARMAN AVENUE
IRVINE, CA 92714

PLEASE FURNISH THIS COMPANY WITH THE ITEMS SPECIFIED BELOW SUBJECT TO THE CONDITIONS ON THE FACE HEREOF AND ON ATTACHED ITTEOPD FORM P001, "CONDITIONS OF PURCHASE." ACCEPTANCE BY SELLER IS LIMITED TO THE EXACT TERMS OF THIS PURCHASE ORDER.

X

20-Jul-81 JARNIGAN B.P. DAAB07-78-C-2922 DO-A7

UPS BLUE NET 30 15530 0 0 X

DESCRIPTION

1000 CYCLES PER 6.4.5.
PARA. 6.11 'TWIST': AGREED THAT ADDITIONAL STRAIN RELIEF MAY BE REQUIRED TO MEET TWIST TEST REQUIREMENTS AND MAY BE DETERMINED DURING QUALIFICATION PROGRAM.
PARA 6.12 'CROSSTALK': NOT APPLICABLE.

D. C. MINOR SENIOR BUYER

X DO NOT BILL TAX

ITT ELECTRO-OPTICAL PRODUCTS DIVISION

BY BUYER DC Minor

* NOTE: IF VENDOR PROMISED DELIVERY DATES SHOWN ABOVE CANNOT BE MET NOTIFY BUYER IMMEDIATELY

ORIGINAL PURCHASE ORDER

SECONDARY STANDARDS

Secondary Standards in possession of and controlled by Electronic Standards Laboratory, Hughes Newport Beach, and used in calibration of transfer and working standards.

The calibration of the equipment is directly traceable to Primary Standards in possession of and controlled by the Primary Standards Laboratory, Hughes Aircraft Company, Centinella and Teal Streets, Culver City, California. They, in turn, show traceability to the National Bureau of Standards.

TEST EQUIPMENT

NOUN	TEST	MODEL
TEST FIXTURE	DURABILITY	
TEST FIXTURE	CABLE RETENTION	
TEST FIXTURE	FLEX LIFE	
TEST FIXTURE	TWIST	
INSTRON TESTER	DURABILITY	1123
CHAMBER	FLEX LIFE	THERMODYNAMIC
MICROPROCESSOR	FLEX LIFE	MICRO-PRO 1000
CHART RECORDER	FLEX LIFE	MICROSERVO
COMPUTER HEWLETT PACKARD	ALL	85
DATA ACQUISITION UNIT HEWLETT PACKARD	ALL	3497A
DIGITAL VOLTMETER HEWLETT PACKARD	ALL	3456A
SOURCE BOX'S	ALL	
DETECTOR BOX'S	ALL	
POWERSUPPLIES	ALL	HP6216A

TEST SCHEDULE

SUBGROUP I

Examination
Coupling Loss
Mating Durability
Examination
Coupling Loss
Immersion
Examination
Coupling Loss
Cable Retention
Examination
Coupling Loss

SUBGROUP II

Examination
Coupling Loss
Mating Durability
Examination
Coupling Loss
Cable Retention
Examination
Coupling Loss

SUBGROUP III

Examination
Coupling Loss
Mating Durability
Examination
Coupling Loss
Immersion
Examination
Coupling Loss
Flex Life
Examination
Coupling Loss

TEST SCHEDULE, CONT.

SUBGROUP IV

- Examination
- Coupling Loss
- Mating Durability
- Examination
- Coupling Loss
- Twist
- Examination
- Coupling Loss

SUBGROUP V

- Examination
- Coupling Loss
- Flex Life
- Examination
- Coupling Loss

SUBGROUP VI

- Examination
- Coupling Loss
- Twist
- Examination
- Coupling Loss

SUBGROUP I

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
VISUAL EXAMINATION	6-23-82	6-23-82
	SPECIFICATION CD1699	PARAG. 6.1
PART NO.	TESTED BY A C076	TEMP 21.7°c R.H. 57%

REQUIREMENTS: When tested per the specification all test samples shall meet the requirements of the applicable documents.

PROCEDURES: The connectors were visually inspected to meet the requirements.

TEST SAMPLES: # 1

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENT.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
BASE LINE INSERTION LOSS	6-23-82	6-23-82
	SPECIFICATION	PARAG.
	CD 1699	6.2.3.1
PART NO.	TESTED BY	TEMP / R.H.
	CD 75	21.7°C 57%

REQUIREMENT: Prepare a 20m length of optical cable for each test sample using appropriate preparation techniques.

PROCEDURE: The baseline measurements were performed as follows: The uncut cable and reference fibers were installed on the transmitter for a series of optical power measurements to establish the initial power ratio for each fiber in the cable to the reference fiber. These values form the basis for all subsequent insertion loss readings. After the characterization was completed, the cable was cut and a mating pair of connectors were installed rejoining the original fibers. A new set of optical power ratios were taken to determine the coupling loss for each fiber. The insertion loss was the difference between the current power ratio for a given fiber and the power ratio obtained during the characterization phase.

Loss (db) = Current power ratio (db) -
Initial power ratio (db)

TEST EQUIPMENT:
COMPUTOR 85
DATA ACQUISITION UNIT
DIGITAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS

TEST SAMPLES: #1

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS.
SEE PAGE No. 78

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
INSERTION LOSS	7-22-82	7-22-82
	SPECIFICATION CD 1699	PARAG. 6.2.5
PART NO.	TESTED BY	TEMP 22.2°C R.H. 68%

REQUIREMENT: The insertion loss of a mated pair of connectors each assembled to a length of cable will be measured on an individual optical channel basis. The objective is 1.5 db.

PROCEDURE: The optical transmitter was connected to a dc power source. The transmitter was allowed sufficient time to warm up to operating temperature before any measurements were taken. The reference fiber was connected to the reference port of the optical multimeter. The test fiber was connected to the signal port of the multimeter. The current power ratio (cpr) indicated by the multimeter was recorded. This process was repeated for each of the test fibers in each cable.

PRD (db) = CPR (db) - IPR (db)

TEST EQUIPMENT:
COMPUTOR 85
DATA ACQUISITION UNIT
DIITAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS

TEST SAMPLES: #6

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS. SEE PAGE No. 122

DATA, PHOTOGRAPHS, & CHARTS

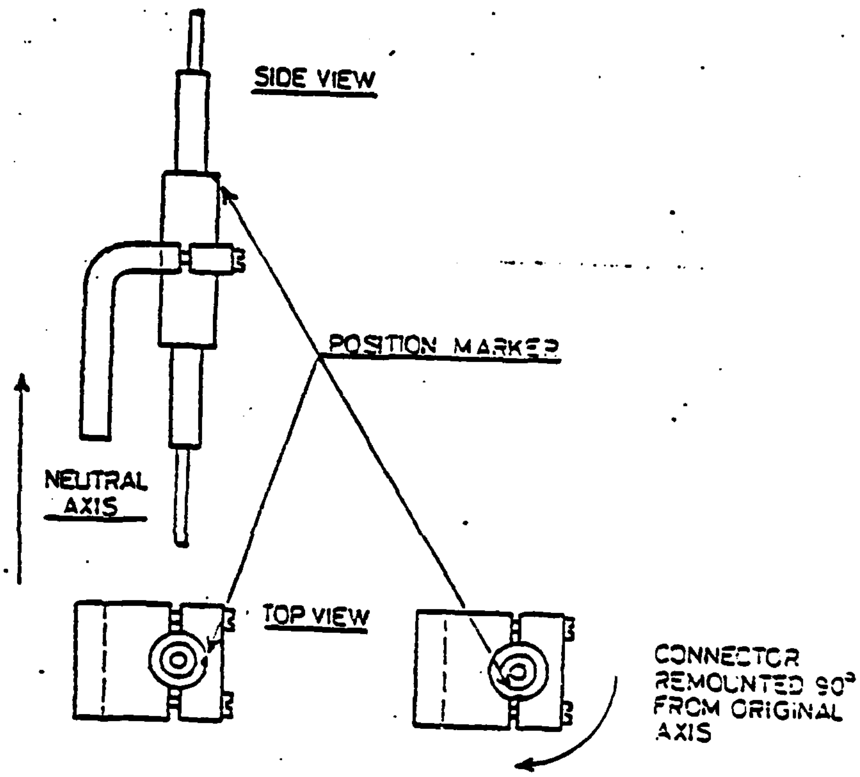


Fig. 1 A Flexing Apparatus Deenergized.

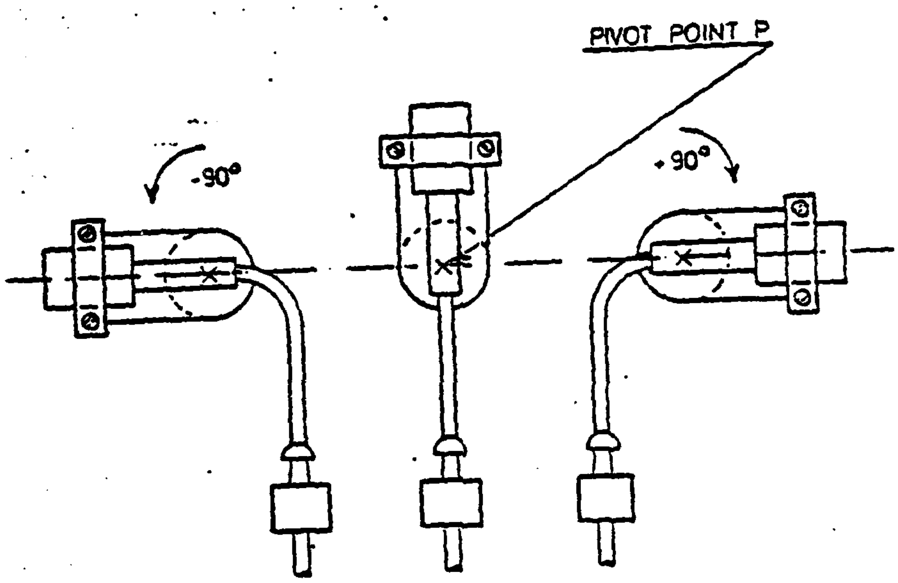


Fig. 12 Fixture Configuration Flexing Action.

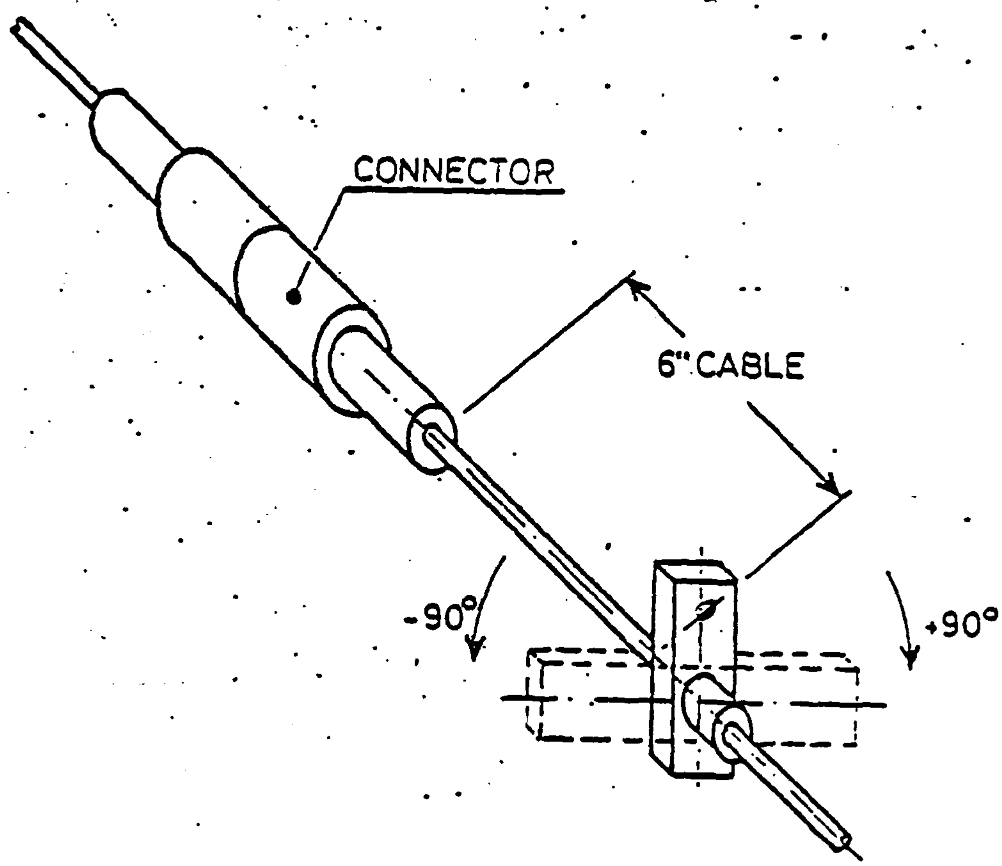


Fig 3 Cable During Twisting Action.

SAMPLE NO 1
TEST TIME 06:23:08:11:46

CURRENT RECORD= 2
MONITOR VOLTAGE +1 089E-002
POWER FACTOR=95 013E-002

CHAN NO.	LINK (dB)	FIBER (dB)	CONN (dB)
1	-.96	+.00	-.96
2	-1 08	-.03	-1 05
3	-1 22	+.02	-1.24
4	-1 26	+.02	-1.27
5	-1 5[illegible]	-.00	-1.[illegible]
6	-.93	-.03	-.90

SAMPLE NO 2
TEST TIME 06:23:08:12:00

CURRENT RECORD= 2
MONITOR VOLTAGE +1 074E-002
POWER FACTOR=91 230E-002

CHAN NO.	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1 16	+.01	-1 17
2	-1 30	+.01	-1.31
3	-1 1[illegible]	-.00	-1 18
4	-1 37	-.07	-1 30
5	-1 [illegible]	-.06	-1.[illegible]
6	-1 62	-.01	-1.63

SAMPLE NO 3
TEST TIME 06:23:08:12:13

CURRENT RECORD= 2
MONITOR VOLTAGE +3 745E-003
POWER FACTOR=96 [illegible]E-002

CHAN NO.	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.[illegible]	-.00	-1.51
2	-1.[illegible]	-.0[illegible]	-1.36
3	-1.[illegible]	-.0[illegible]	-1.50
4	-1.[illegible]	-.0[illegible]	-1.5[illegible]
5	-1.58	-.05	-1.54
6	-1.60	+.00	-1.60

SAMPLE NO 4
TEST TIME 06:23:08:12:26

CURRENT RECORD= 2
MONITOR VOLTAGE +5 116E-003
POWER FACTOR=75 453E-002

CHAN NO.	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1 31	+.06	-1.37
2	-1.24	-.00	-1.24
3	-1 00	-.01	-.99
4	-.98	-.00	-.97
5	-1.52	-.05	-1.46
6	-1 56	-.00	-1.56

SAMPLE NO. 5
TEST TIME 06:23:08:12:39

CURRENT RECORD= 2
MONITOR VOLTAGE +3 343E-003
POWER FACTOR=96 024E-002

CHAN NO.	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1 04	-.00	-1.04
2	-1 11	-.03	-1.08
3	-1 32	-.01	-1.31
4	-1 18	-.01	-1.17
5	-1 18	-.01	-1.37
6	-1 02	-.00	-1.01

SAMPLE NO 6
TEST TIME 06:23:08:12:52

CURRENT RECORD= 2
MONITOR VOLTAGE +2.461E-003
POWER FACTOR=94 312E-002

CHAN NO.	LINK (dB)	FIBER (dB)	CONN (dB)
1	-.92	+.01	-.93
2	-.[illegible]	+.0[illegible]	-1.00
3	-.[illegible]	-.0[illegible]	-.[illegible]
4	-1.04	-.00	-1.04
5	-.78	+.06	-.84
6	-.81	+.06	-.87

BASE LINE INSERTION LOSS

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
INSERTION LOSS	6-23-82	6-23-82
	SPECIFICATION CD 1699	PARAG. 6.2.5
PART NO.	TESTED BY QC 075	TEMP 21.7°C R.H. 57%

REQUIREMENT: The insertion loss of a mated pair of connectors each assembled to a length of cable will be measured on an individual optical channel basis. The objective is 1.5 db.

PROCEDURE: The optical transmitter was connected to a dc power source. The transmitter was allowed sufficient time to warm up to operating temperature before any measurements were taken. The reference fiber was connected to the reference port of the optical multimeter. The test fiber was connected to the signal port of the multimeter. The current power ratio (cpr) indicated by the multimeter was recorded. This process was repeated for each of the test fibers in each cable.

PRD (db) = CPR (db) - IPR (db)

TEST EQUIPMENT:
COMPUTOR 85
DATA ACQUISITION UNIT
DIITAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS

TEST SAMPLES: #1

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS.
SEE PAGE No. 79

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
MATING DURABILITY	6-23-82	6-25-82
	SPECIFICATION CD 1699	PARAG. 6.4
PART NO.	TESTED BY HAC CD 76	TEMP 22.8°C R.H. 55%

REQUIREMENTS: Counterpart connectors will be capable of meeting the requirements of succeeding tests after 1000 mating and unmating cycles without additional lubrication of the coupling devices. The connector mating faces may be cleaned after every 50 cycles.

PROCEDURE: The receptacle connector was mounted to a simulated panel with its jam nut. The optical transmitter was connected to a dc power source. The plug connector was aligned and engaged with the receptacle, being rotated until the connectors were fully engaged. Then the coupling ring was rotated in the opposite direction until connectors were fully uncoupled. The two connector halves were completely separated. This process was repeated for a total of 1,000 cycles. No lubrication was applied during this testing.

TEST EQUIPMENT:
COMPUTOR 85
DATA ACQUISITION UNIT
DIGITAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS
DURABILITY TEST FIXTURE

TEST SAMPLES: #1

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
VISUAL EXAMINATION	6-25-82	6-25-82
	SPECIFICATION CD1699	PARAG. 6.1
PART NO.	TESTED BY	TEMP 22.8°C R.H. 55%

REQUIREMENTS: When tested per the specification all test samples shall meet the requirements of the applicable documents.

PROCEDURES: The connectors were visually inspected to meet the requirements.

TEST SAMPLES: #1

TEST RESULTS: THE TEST SAMPLE MET THE SPECIFICATION REQUIREMENTS.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
INSERTION LCSS	6-25-82	6-25-82
	SPECIFICATION CD 1699	PARAG. 6.2.5
PART NO.	TESTED BY	TEMP 22.8°C R.H. 55%

REQUIREMENT: The insertion loss of a mated pair of connectors each assembled to a length of cable will be measured on an individual optical channel basis. The objective is 1.5 db.

PROCEDURE: The optical transmitter was connected to a dc power source. The transmitter was allowed sufficient time to warm up to operating temperature before any measurements were taken. The reference fiber was connected to the reference port of the optical multimeter. The test fiber was connected to the signal port of the multimeter. The current power ratio (cpr) indicated by the multimeter was recorded. This process was repeated for each of the test fibers in each cable.

PRD (db) = CPR (db) - IPR (db)

TEST EQUIPMENT:

COMPUTOR 85
DATA ACQUISITION UNIT
DIITAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS

TEST SAMPLES: #1

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS. SEE PAGE No. 83

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
IMMERSION	6-25-82	6-28-82
	SPECIFICATION CD 1699	PARAG. 6.6
PART NO.	TESTED BY	TEMP 22.8°C R.H. 62%

REQUIREMENT: The mated connectors shall exclude water from the sealed interior portions when immersed in water to a depth of 1.83m. The connectors shall maintain continuity throughout the exposure and shall meet the insertion loss requirement at the conclusion of the exposure.

PROCEDURE: The mated connectors were installed inside the water container with the transmitter and detector fiber optic cable brought outside through suitable seals to withstand the test pressure. With the optical transmitter connected to a DC power source, the water vessel was filled with room temperature tap water to completely cover the mated connector pairs. The water vessel was then placed in an altitude chamber, and pressurized to 18KPa for a period of 24 hours.

TEST EQUIPMENT:
COMPUTOR 85
DATA ACQUISITION UNIT
DIGITAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS

TEST SAMPLES: #1

TEST RESULTS: SEE ABSTACT FOR RESULTS.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
VISUAL EXAMINATION	6-28-82	6-28-82
	SPECIFICATION: CD1699	PARAG.: 5.1
PART NO.	TESTED BY	TEMP 22.8° R.H. 62%

REQUIREMENTS: When tested per the specification all test samples shall meet the requirements of the applicable documents.

PROCEDURES: The connectors were visually inspected to meet the requirements.

TEST SAMPLES: #1

TEST RESULTS: SEE ABSTRACT FOR RESULTS.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
INSERTION LOSS	6-28-82	6-28-82
	SPECIFICATION CD 1699	PARAG. 6.2.5
PART NO.	TESTED BY	TEMP 22.8°C R.H. 62%

REQUIREMENT: The insertion loss of a mated pair of connectors each assembled to a length of cable will be measured on an individual optical channel basis. The objective is 1.5 db.

PROCEDURE: The optical transmitter was connected to a dc power source. The transmitter was allowed sufficient time to warm up to operating temperature before any measurements were taken. The reference fiber was connected to the reference port of the optical multimeter. The test fiber was connected to the signal port of the multimeter. The current power ratio (cpr) indicated by the multimeter was recorded. This process was repeated for each of the test fibers in each cable.

PRD (db) = CPR (db) - IPR (db)

TEST EQUIPMENT: COMPUTOR 85
DATA ACQUISITION UNIT
DIITAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS

TEST SAMPLES: #1

TEST RESULTS: SEE ABSTRACT & PAGE No. 105

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
CABLE RETENTION	7-21-82	7-22-82
	SPECIFICATION CD 1699	PARAG. 6.9
PART NO.	TESTED BY HAC CD 76	TEMP 22°C R.H. 68%

REQUIREMENTS: The plug and receptacle samples shall withstand a tensile load of 1780 N (400 lbs) for a period of 60 seconds without physical damage and shall be capable of meeting the requirements of succeeding tests.

PROCEDURE: With the receptacle mounted on a mounting fixture with its jam nut, the receptacle was installed in the upright position. Five turns min. were wrapped around a 15.75 dia mandrel, with no excess slack between the back side of the connector and the mandrel. There was a minimum of 160mm separation between the rear of the connector and the first turn on the mandrel. After which the plug and receptacle were mated, the mounting fixture turned 180° so that the plug connector could be tested in the same manner. After both halves of the connector were tested, they were carefully examined.

TEST EQUIPMENT:
COMPUTOR 85
DATA ACQUISITION UNIT
DIGITAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS
INSTRON TESTER
CABLE RETENTION-TEST FIXTURE

TEST SAMPLES: #1

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
VISUAL EXAMINATION	7-22-82	7-22-82
	SPECIFICATION CD1699	PARAG. 6.1
PART NO.	TESTED BY	TEMP 22.2°C R.H. 68%

REQUIREMENTS: When tested per the specification all test samples shall meet the requirements of the applicable documents.

PROCEDURES: The connectors were visually inspected to meet the requirements.

TEST SAMPLES: #1

TEST RESULTS: THE TEST SAMPLE MET THE SPECIFICATION REQUIREMENTS.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
INSERTION LOSS	7-22-82	7-22-82
	SPECIFICATION	PARAG.
	CD 1699	6.2.5
PART NO.	TESTED BY	TEMP 22.2°C R.H. 68%

REQUIREMENT: The insertion loss of a mated pair of connectors each assembled to a length of cable will be measured on an individual optical channel basis. The objective is 1.5 db.

PROCEDURE: The optical transmitter was connected to a dc power source. The transmitter was allowed sufficient time to warm up to operating temperature before any measurements were taken. The reference fiber was connected to the reference port of the optical multimeter. The test fiber was connected to the signal port of the multimeter. The current power ratio (cpr) indicated by the multimeter was recorded. This process was repeated for each of the test fibers in each cable.

PRD (db) = CPR (db) - IPR (db)

TEST EQUIPMENT:

COMPUTCR 85
DATA ACQUISITION UNIT
DIITAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS

TEST SAMPLES: #1

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS. SEE PAGE No. 122

SUBGROUP II

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
VISUAL EXAMINATION	6-23-82	6-23-82
	SPECIFICATION	PARAG.
	CD1699	6.1
PART NO.	TESTED BY	TEMP R.H.
		21.7° 57%

REQUIREMENTS: When tested per the specification all test samples shall meet the requirements of the applicable documents.

PROCEDURES: The connectors were visually inspected to meet the requirements.

TEST SAMPLES: # 2

TEST RESULTS: THE TEST SAMPLE MET THE SPECIFICATION REQUIREMENT.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
BASE LINE INSERTION LOSS	6-23-82	6-23-82
	SPECIFICATION CD 1699	PARAG. 6.2.3.1
PART NO.	TESTED BY CD 76	TEMP 21.7° R.H. 57%

REQUIREMENT: Prepare a 20m length of optical cable for each test sample using appropriate preparation techniques.

PROCEDURE: The baseline measurements were performed as follows: The uncut cable and reference fibers were installed on the transmitter for a series of optical power measurements to establish the initial power ratio for each fiber in the cable to the reference fiber. These values form the basis for all subsequent insertion loss readings. After the characterization was completed, the cable was cut and a mating pair of connectors were installed rejoining the original fibers. A new set of optical power ratios were taken to determine the coupling loss for each fiber. The insertion loss was the difference between the current power ratio for a given fiber and the power ratio obtained during the characterization phase.

Loss (db) = Current power ratio (db) - Initial power ratio (db)

TEST EQUIPMENT:
COMPUTOR 85
DATA ACQUISITION UNIT
DIGITAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS

TEST SAMPLES: #2

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS.
SEE PAGE No. 78

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
INSERTION LOSS	6-23-82	6-23-82
	SPECIFICATION CD 1699	PARAG. 6.2.5
PART NO.	TESTED BY	TEMP 21.7°C R.H. 57%

REQUIREMENT: The insertion loss of a mated pair of connectors each assembled to a length of cable will be measured on an individual optical channel basis. The objective is 1.5 db.

PROCEDURE: The optical transmitter was connected to a dc power source. The transmitter was allowed sufficient time to warm up to operating temperature before any measurements were taken. The reference fiber was connected to the reference port of the optical multimeter. The test fiber was connected to the signal port of the multimeter. The current power ratio (cpr) indicated by the multimeter was recorded. This process was repeated for each of the test fibers in each cable.

PRD (db) = CPR (db) - IPR (db)

TEST EQUIPMENT:
COMPUTOR 85
DATA ACQUISITION UNIT
DIITAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS

TEST SAMPLES: #2

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS. SEE PAGE No. 79

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
MATING DURABILITY	6-23-82	6-25-82
	SPECIFICATION CD 1699	PARAG. 6.4
PART NO.	TESTED BY CD 76	TEMP 22.8° R.H. 55%

REQUIREMENTS: Counterpart connectors will be capable of meeting the requirements of succeeding tests after 1000 mating and unmating cycles without additional lubrication of the coupling devices. The connector mating faces may be cleaned after every 50 cycles.

PROCEDURE: The receptacle connector was mounted to a simulated panel with its jam nut. The optical transmitter was connected to a dc power source. The plug connector was aligned and engaged with the receptacle, being rotated until the connectors were fully engaged. Then the coupling ring was rotated in the opposite direction until connectors were fully uncoupled. The two connector halves were completely separated. This process was repeated for a total of 1,000 cycles. No lubrication was applied during this testing.

TEST EQUIPMENT:

- COMPUTOR 85
- DATA ACQUISITION UNIT
- DIGITAL VOLTMETER
- POWER SUPPLYS
- SOURCE BOXS
- DETECTOR BOXS
- DURABILITY TEST FIXTURE

TEST SAMPLES: #2

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
VISUAL EXAMINATION	6-25-82	6-25-82
	SPECIFICATION: CD1699	PARAG.: 6.1
PART NO.	TESTED BY: QC 4 CD76	TEMP: 22.8°C R.H.: 55%

REQUIREMENTS: When tested per the specification all test samples shall meet the requirements of the applicable documents.

PROCEDURES: The connectors were visually inspected to meet the requirements.

TEST SAMPLES: #2

TEST RESULTS: THE TEST SAMPLE MET THE SPECIFICATION REQUIREMENT.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
INSERTION LOSS	6-25-82	6-25-82
	SPECIFICATION CD 1699	PARAG. 6.2.5
ART NO.	TESTED BY	TEMP 22.8° R.H. 55%

REQUIREMENT: The insertion loss of a mated pair of connectors each assembled to a length of cable will be measured on an individual optical channel basis. The objective is 1.5 db.

PROCEDURE: The optical transmitter was connected to a dc power source. The transmitter was allowed sufficient time to warm up to operating temperature before any measurements were taken. The reference fiber was connected to the reference port of the optical multimeter. The test fiber was connected to the signal port of the multimeter. The current power ratio (cpr) indicated by the multimeter was recorded. This process was repeated for each of the test fibers in each cable.

PRD (db) = CPR (db) - IPR (db)

TEST EQUIPMENT:
COMPUTOR 85
DATA ACQUISITION UNIT
DIITAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS

TEST SAMPLES: #2

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS. SEE PAGE No. 83

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
CABLE RETENTION	7-22-82	7-22-82
	SPECIFICATION CD 1699	PARAG. 6.9
PART NO.	TESTED BY	TEMP 22.2° R.H. 68%

REQUIREMENTS: The plug and receptacle samples shall withstand a tensile load of 1780 N (400 lbs) for a period of 60 seconds without physical damage and shall be capable of meeting the requirements of succeeding tests.

PROCEDURE: With the receptacle mounted on a mounting fixture with its jam nut, the receptacle was installed in the upright position. Five turns min. were wrapped around a 15.75 dia mandrel, with no excess slack between the back side of the connector and the mandrel. There was a minimum of 160mm separation between the rear of the connector and the first turn on the mandrel. After which the plug and receptacle were mated, the mounting fixture turned 180° so that the plug connector could be tested in the same manner. After both halves of the connector were tested, they were carefully examined.

TEST EQUIPMENT:
COMPUTOR 85
DATA ACQUISITION UNIT
DIGITAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS
INSTRON TESTER
CABLE RETENTION-TEST FIXTURE

TEST SAMPLES: #2

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
VISUAL EXAMINATION	7-22-82	7-22-82
	SPECIFICATION CD1699	PARAG. 6.1
PART NO.	TESTED BY	TEMP 22.2° R.H. 68%

REQUIREMENTS: When tested per the specification all test samples shall meet the requirements of the applicable documents.

PROCEDURES: The connectors were visually inspected to meet the requirements.

TEST SAMPLES: #2

TEST RESULTS: THE TEST SAMPLE MET THE SPECIFICATION REQUIREMENT.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
INSERTION LOSS	7-22-82	7-22-82
	SPECIFICATION CD 1699	PARAG. 6.2.5
PART NO.	TESTED BY	TEMP 22.2°C R.H. 68%

REQUIREMENT: The insertion loss of a mated pair of connectors each assembled to a length of cable will be measured on an individual optical channel basis. The objective is 1.5 db.

PROCEDURE: The optical transmitter was connected to a dc power source. The transmitter was allowed sufficient time to warm up to operating temperature before any measurements were taken. The reference fiber was connected to the reference port of the optical multimeter. The test fiber was connected to the signal port of the multimeter. The current power ratio (cpr) indicated by the multimeter was recorded. This process was repeated for each of the test fibers in each cable.

PRD (db) = CPR (db) - IPR (db)

TEST EQUIPMENT:
COMPUTOR 85
DATA ACQUISITION UNIT
DITAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS

TEST SAMPLES: #2

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS. SEE PAGE No. 122

SUBGROUP III

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
VISUAL EXAMINATION	6-23-82	6-23-82
	SPECIFICATION: CD1699	PARAG.: 6.1
PART NO.	TESTED BY: QC 4 CD 76	TEMP 21.7° R.H. 57%

REQUIREMENTS: When tested per the specification all test samples shall meet the requirements of the applicable documents.

PROCEDURES: The connectors were visually inspected to meet the requirements.

TEST SAMPLES: #3

TEST RESULTS: THE TEST SAMPLE MET THE SPECIFICATION REQUIREMENT.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
BASE LINE INSERTION LOSS	6-23-82	6-23-82
	SPECIFICATION	PARAG.
	CD 1699	6.2.3.1
PART NO.	TESTED BY	TEMP R.H.
		21.7°C 52%

REQUIREMENT: Prepare a 20m length of optical cable for each test sample using appropriate preparation techniques.

PROCEDURE: The baseline measurements were performed as follows: The uncut cable and reference fibers were installed on the transmitter for a series of optical power measurements to establish the initial power ratio for each fiber in the cable to the reference fiber. These values form the basis for all subsequent insertion loss readings. After the characterization was completed, the cable was cut and a mating pair of connectors were installed rejoining the original fibers. A new set of optical power ratios were taken to determine the coupling loss for each fiber. The insertion loss was the difference between the current power ratio for a given fiber and the power ratio obtained during the characterization phase.

Loss (db) = Current power ratio (db) -
Initial power ratio (db)

TEST EQUIPMENT:
COMPUTOR 85
DATA ACQUISITION UNIT
DIGITAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS

TEST SAMPLES: #3

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS.
SEE PAGE No. 78

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
INSERTION LOSS	6-23-82	6-23-82
	SPECIFICATION CD 1699	PARAG. 6.2.5
PART NO.	TESTED BY	TEMP 21.7° R.H. 57%

REQUIREMENT: The insertion loss of a mated pair of connectors each assembled to a length of cable will be measured on an individual optical channel basis. The objective is 1.5 db.

PROCEDURE: The optical transmitter was connected to a dc power source. The transmitter was allowed sufficient time to warm up to operating temperature before any measurements were taken. The reference fiber was connected to the reference port of the optical multimeter. The test fiber was connected to the signal port of the multimeter. The current power ratio (cpr) indicated by the multimeter was recorded. This process was repeated for each of the test fibers in each cable.

PRD (db) = CPR (db) - IPR (db)

TEST EQUIPMENT:

COMPUTOR 85
DATA ACQUISITION UNIT
DIITAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS

TEST SAMPLES: #3

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS. SEE PAGE No. 29

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
MATING DURABILITY	6-23-82	6-25-82
	SPECIFICATION CD 1699	PARAG. 6.4
PART NO.	TESTED BY:	TEMP 22.8° R.H. 62%

REQUIREMENTS: Counterpart connectors will be capable of meeting the requirements of succeeding tests after 1000 mating and unmating cycles without additional lubrication of the coupling devices. The connector mating faces may be cleaned after every 50 cycles.

PROCEDURE: The receptacle connector was mounted to a simulated panel with its jam nut. The optical transmitter was connected to a dc power source. The plug connector was aligned and engaged with the receptacle, being rotated until the connectors were fully engaged. Then the coupling ring was rotated in the opposite direction until connectors were fully uncoupled. The two connector halves were completely separated. This process was repeated for a total of 1,000 cycles. No lubrication was applied during this testing.

TEST EQUIPMENT:
- COMPUTOR 85
- DATA ACQUISITION UNIT
- DIGITAL VOLTMETER
- POWER SUPPLYS
- SOURCE BOXS
- DETECTOR BOXS
- DURABILITY TEST FIXTURE

TEST SAMPLES: #3

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
VISUAL EXAMINATION	6-25-82	6-25-82
	SPECIFICATION CD1699	PARAG. 6.1
PART NO.	TESTED BY CD 76	TEMP 22.8°C R.H. 62%

REQUIREMENTS: When tested per the specification all test samples shall meet the requirements of the applicable documents.

PROCEDURES: The connectors were visually inspected to meet the requirements.

TEST SAMPLES: #3

TEST RESULTS: THE TEST SAMPLE MET THE SPECIFICATION REQUIREMENT.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
INSERTION LOSS	6-25-82	6-25-82
	SPECIFICATION CD 1699	PARAG. 6.2.5
PART NO.	TESTED BY/ 2076	TEMP 22.8°C R.H. 62%

REQUIREMENT: The insertion loss of a mated pair of connectors each assembled to a length of cable will be measured on an individual optical channel basis. The objective is 1.5 db.

PROCEDURE: The optical transmitter was connected to a dc power source. The transmitter was allowed sufficient time to warm up to operating temperature before any measurements were taken. The reference fiber was connected to the reference port of the optical multimeter. The test fiber was connected to the signal port of the multimeter. The current power ratio (cpr) indicated by the multimeter was recorded. This process was repeated for each of the test fibers in each cable.

PRD (db) = CPR (db) - IPR (db)

TEST EQUIPMENT: COMPUTOR 85
DATA ACQUISITION UNIT
DITAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS

TEST SAMPLES: #3

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS.
SEE PAGE No. 104

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
IMMERSION	6-26-82	6-28-82
	SPECIFICATION	PARAG.
	CD 1699	6.6
PART NO.	TESTED BY	TEMP 22.8°C R.H. 62%

REQUIREMENT: The mated connectors shall exclude water from the sealed interior portions when immersed in water to a depth of 1.83m. The connectors shall maintain continuity throughout the exposure and shall meet the insertion loss requirement at the conclusion of the exposure.

PROCEDURE: The mated connectors were installed inside the water container with the transmitter and detector fiber optic cable brought outside through suitable seals to withstand the test pressure. With the optical transmitter connected to a DC power source, the water vessel was filled with room temperature tap water to completely cover the mated connector pairs. The water vessel was then placed in an altitude chamber, and pressurized to 18KPa for a period of 24 hours.

TEST EQUIPMENT:

COMPUTOR 85
DATA ACQUISITION UNIT
DIGITAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS

TEST SAMPLES: #3

TEST RESULTS: SEE ABSTRACT FOR RESULTS

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
VISUAL EXAMINATION	6-28-82	6-28-82
	SPECIFICATION: CD1699	PARAG.: 6.1
PART NO.	TESTED BY	TEMP 22.8°C R.H. 62%

REQUIREMENTS: When tested per the specification all test samples shall meet the requirements of the applicable documents.

PROCEDURES: The connectors were visually inspected to meet the requirements.

TEST SAMPLES: #3

TEST RESULTS: SEE ABSTACT FOR RESULTS.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
INSERTION LOSS	6-28-82	6-28-82
	SPECIFICATION CD 1699	PARAG. 6.2.5
PART NO.	TESTED BY	TEMP 22.8°C R.H. 62%

REQUIREMENT: The insertion loss of a mated pair of connectors each assembled to a length of cable will be measured on an individual optical channel basis. The objective is 1.5 db.

PROCEDURE: The optical transmitter was connected to a dc power source. The transmitter was allowed sufficient time to warm up to operating temperature before any measurements were taken. The reference fiber was connected to the reference port of the optical multimeter. The test fiber was connected to the signal port of the multimeter. The current power ratio (cpr) indicated by the multimeter was recorded. This process was repeated for each of the test fibers in each cable.

PRD (db) = CPR (db) - IPR (db)

TEST EQUIPMENT:
COMPUTOR 85
DATA ACQUISITION UNIT
DIITAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS

TEST SAMPLES: #3

SEE ABSTRACT FOR RESULTS.

TEST RESULTS: SEE PAGE No. 105

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
FLEX LIFE	7-9-82	7-15-82
	SPECIFICATION: CD 1699	PARAG.: 6.10
PART NO.	TESTED BY: 4 CD76	TEMP: 21.7°c R.H.: 60%

REQUIREMENT: With the test connectors setup per Fig. 1, the connector shall be cycled per Paragraph 6.10.3 of CD1699. Monitoring CPR initially and periodically throughout the exposure. These measurements shall not be considered a formal insertion loss measurement, they should be for verifying continuity only. A visual examination shall be performed after each portion of the flex testing is completed, paying particular attention to the cable where it is protected by the connector strain relief.

PROCEDURE: With the test connector installed into a test fixture per Fig. 1, the test connector was then flexed per Fig. 2 for 1000 cycles. At the completion of 1000 cycles the connector was rotated 90° and cycled 1000 times in this axis, after which a visual examination was performed for evidence of deterioration. The test connector and test fixture were installed into a test chamber at 70°c (±2°) for a period of at least 48 hours. The chamber was then programmed to -55°c (±3°) for a period of 48 hours. At the conclusion of the 48 hours and while the connector was still exposed to -55°c, the test connector was subjected to 500 cycles of flex, at the completion of 500 cycles the test connector was rotated 90° and subjected to 500 more cycles. CPR was monitored throughout the complete flex life test.

TEST EQUIPMENT:
- COMPUTOR 85
- DATA ACQUISITION UNIT
- DIGITAL VOLTMETER
- POWER SUPPLYS
- SOURCE BOXS
- DETECTOR BOXS
- FLEX TEST FIXTURE
- TEMPERATURE CHAMBER
- MICROPROCESSOR

TEST SAMPLES: #3

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
VISUAL EXAMINATION	7-22-82	7-22-82
	SPECIFICATION CD1699	PARAG. 6.1
PART NO.	TESTED BY CD 76	TEMP 22.2° R.H. 68%

REQUIREMENTS: When tested per the specification all test samples shall meet the requirements of the applicable documents.

PROCEDURES: The connectors were visually inspected to meet the requirements.

TEST SAMPLES: #3

TEST RESULTS: THE TEST SAMPLE MET THE SPECIFICATION REQUIREMENT.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
INSERTION LOSS	7-22-82	7-22-82
	SPECIFICATION	PARAG.
	CD 1699	6.2.5
ART NO.	TESTED BY	TEMP • R.H.
		22.2 C 68%

REQUIREMENT: The insertion loss of a mated pair of connectors each assembled to a length of cable will be measured on an individual optical channel basis. The objective is 1.5 db.

PROCEDURE: The optical transmitter was connected to a dc power source. The transmitter was allowed sufficient time to warm up to operating temperature before any measurements were taken. The reference fiber was connected to the reference port of the optical multimeter. The test fiber was connected to the signal port of the multimeter. The current power ratio (cpr) indicated by the multimeter was recorded. This process was repeated for each of the test fibers in each cable.

PRD (db) = CPR (db) - IPR (db)

TEST EQUIPMENT:
COMPUTOR 85
DATA ACQUISITION UNIT
DITIAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS

TEST SAMPLES: #3

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS.
SEE PAGE No. 122

SUBGROUP IV

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
VISUAL EXAMINATION	6-23-82	6-23-82
	SPECIFICATION: CD1699	PARAG.: 6.1
PART NO.	TESTED BY: QC 76	TEMP: 21.7°C R.H.: 57%

REQUIREMENTS: When tested per the specification all test samples shall meet the requirements of the applicable documents.

PROCEDURES: The connectors were visually inspected to meet the requirements.

TEST SAMPLES: #4

TEST RESULTS: THE TEST SAMPLE MET THE SPECIFICATION REQUIREMENT.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
BASE LINE INSERTION LOSS	6-23-82	6-23-82
	SPECIFICATION CD 1699	PARAG. 6.2.3.1
PART NO.	TESTED BY	TEMP 22.7°C R.H. 57%

REQUIREMENT: Prepare a 20m length of optical cable for each test sample using appropriate preparation techniques.

PROCEDURE: The baseline measurements were performed as follows: The uncut cable and reference fibers were installed on the transmitter for a series of optical power measurements to establish the initial power ratio for each fiber in the cable to the reference fiber. These values form the basis for all subsequent insertion loss readings. After the characterization was completed, the cable was cut and a mating pair of connectors were installed rejoining the original fibers. A new set of optical power ratios were taken to determine the coupling loss for each fiber. The insertion loss was the difference between the current power ratio for a given fiber and the power ratio obtained during the characterization phase.

Loss (db) = Current power ratio (db) - Initial power ratio (db)

TEST EQUIPMENT: COMPUTOR 85, DATA ACQUISITION UNIT, DIGITAL VOLTMETER, POWER SUPPLYS, SOURCE BOXS, DETECTOR BOXS

TEST SAMPLES: #4

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS.
SEE PAGE No. 78

TEST	DATE STARTED	DATE COMPLETED
INSERTION LOSS	6-23-82	6-23-82
	SPECIFICATION CD 1699	PARAG. 6.2.5
PART NO.	TESTED BY QC CD 76	TEMP 21.7° R.H. 57%

REQUIREMENT: The insertion loss of a mated pair of connectors each assembled to a length of cable will be measured on an individual optical channel basis. The objective is 1.5 db.

PROCEDURE: The optical transmitter was connected to a dc power source. The transmitter was allowed sufficient time to warm up to operating temperature before any measurements were taken. The reference fiber was connected to the reference port of the optical multimeter. The test fiber was connected to the signal port of the multimeter. The current power ratio (cpr) indicated by the multimeter was recorded. This process was repeated for each of the test fibers in each cable.

PRD (db) = CPR (db) - IPR (db)

TEST EQUIPMENT:
COMPUTOR 85
DATA ACQUISITION UNIT
DIITAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS

TEST SAMPLES: #4

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS. SEE PAGE No. 79

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
MATING DURABILITY	6-23-82	6-25-82
	SPECIFICATION CD 1699	PARAG. 6.4
PART NO.	TESTED BY	TEMP 22° C R.H. 55%

REQUIREMENTS: Counterpart connectors will be capable of meeting the requirements of succeeding tests after 1000 mating and unmating cycles without additional lubrication of the coupling devices. The connector mating faces may be cleaned after every 50 cycles.

PROCEDURE: The receptacle connector was mounted to a simulated panel with its jam nut. The optical transmitter was connected to a dc power source. The plug connector was aligned and engaged with the receptacle, being rotated until the connectors were fully engaged. Then the coupling ring was rotated in the opposite direction until connectors were fully uncoupled. The two connector halves were completely separated. This process was repeated for a total of 1,000 cycles. No lubrication was applied during this testing.

TEST EQUIPMENT:

- COMPUTOR 85
- DATA ACQUISITION UNIT
- DIGITAL VOLTMETER
- POWER SUPPLYS
- SOURCE BOXS
- DETECTOR BOXS
- DURABILITY TEST FIXTURE

TEST SAMPLES: #4

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
VISUAL EXAMINATION	6-25-82	6-25-82
	SPECIFICATION	PARAG.
	CD1699	5.1
PART NO.	TESTED BY	TEMP 22.8°C R.H. 55%

REQUIREMENTS: When tested per the specification all test samples shall meet the requirements of the applicable documents.

PROCEDURES: The connectors were visually inspected to meet the requirements.

TEST SAMPLES: #4

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENT.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
INSERTION LOSS	6-25-82	6-25-82
	SPECIFICATION CD 1699	PARAG. 6.2.5
PART NO.	TESTED BY	TEMP 22.8°C R.H. 55%

REQUIREMENT: The insertion loss of a mated pair of connectors each assembled to a length of cable will be measured on an individual optical channel basis. The objective is 1.5 db.

PROCEDURE: The optical transmitter was connected to a dc power source. The transmitter was allowed sufficient time to warm up to operating temperature before any measurements were taken. The reference fiber was connected to the reference port of the optical multimeter. The test fiber was connected to the signal port of the multimeter. The current power ratio (cpr) indicated by the multimeter was recorded. This process was repeated for each of the test fibers in each cable.

PRD (db) = CPR (db) - IPR (db)

TEST EQUIPMENT:

COMPUTOR 85
DATA ACQUISITION UNIT
DITAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS

TEST SAMPLES: #4

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS.
SEE PAGE No. 108

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
TWIST	7-19-82	7-19-82
	SPECIFICATION CD1699	PARAG. 6.11
ART NO.	TESTED BY	TEMP 22.8°C R.H. 61%

REQUIREMENT: With test connector set up per Fig. 3 CPR measurements shall be taken initially and periodically throughout the cycling, with these measurements taken only to verify optical continuity. At the conclusion of the 1000 twist cycles the cable and cable retaining feature shall be carefully examined for any damage or deterioration.

PROCEDURE: With the test connector setup per Fig. 3, 1000 cycles of twist cycling was completed. The connector and fiber cable were removed from the test fixture and carefully examined for evidence of damage or deterioration of the cable or connector.

TEST EQUIPMENT:
- COMPUTOR 85
- DATA ACQUISITION UNIT
- DIGITAL VOLTMETER
- POWER SUPPLYS
- SOURCE BOXS
- DETECTOR BOXS
- TWIST TEST FIXTURE

TEST SAMPLES: #4

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENT.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
VISUAL EXAMINATION	7-22-82	7-22-82
	SPECIFICATION CD1699	PARAG. 6.1
PART NO.	TESTED BY	TEMP 22°C R.H. 68%

REQUIREMENTS: When tested per the specification all test samples shall meet the requirements of the applicable documents.

PROCEDURES: The connectors were visually inspected to meet the requirements.

TEST SAMPLES: #4

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENT.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
INSERTION LOSS	7-22-82	7-22-82
	SPECIFICATION CD 1699	PARAG. 6.2.5
PART NO.	TESTED BY CD 76	TEMP 22.2° R.H. 68%

REQUIREMENT: The insertion loss of a mated pair of connectors each assembled to a length of cable will be measured on an individual optical channel basis. The objective is 1.5 db.

PROCEDURE: The optical transmitter was connected to a dc power source. The transmitter was allowed sufficient time to warm up to operating temperature before any measurements were taken. The reference fiber was connected to the reference port of the optical multimeter. The test fiber was connected to the signal port of the multimeter. The current power ratio (cpr) indicated by the multimeter was recorded. This process was repeated for each of the test fibers in each cable.

PRD (db) = CPR (db) - IPR (db)

TEST EQUIPMENT:
COMPUTOR 85
DATA ACQUISITION UNIT
DIITAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS

TEST SAMPLES: #4

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS.
SEE PAGE No. 122

SUBGROUP V

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
VISUAL EXAMINATION	6-23-82	6-23-82
	SPECIFICATION	PARAG.
	CD1699	6.1
PART NO.	TESTED BY QC A CD 76	TEMP 21.7°C R.H. 57%

REQUIREMENTS: When tested per the specification all test samples shall meet the requirements of the applicable documents.

PROCEDURES: The connectors were visually inspected to meet the requirements.

TEST SAMPLES: #5

TEST RESULTS: THE TEST SAMPLE MET THE SPECIFICATION REQUIREMENT.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
BASE LINE INSERTION LOSS	6-23-82	6-23-82
	SPECIFICATION CD 1699	PARAG. 6.2.3.1
PART NO.	TESTED BY CD 76	TEMP 21.7°C R.H. 52%

REQUIREMENT: Prepare a 20m length of optical cable for each test sample using appropriate preparation techniques.

PROCEDURE: The baseline measurements were performed as follows: The uncut cable and reference fibers were installed on the transmitter for a series of optical power measurements to establish the initial power ratio for each fiber in the cable to the reference fiber. These values form the basis for all subsequent insertion loss readings. After the characterization was completed, the cable was cut and a mating pair of connectors were installed rejoining the original fibers. A new set of optical power ratios were taken to determine the coupling loss for each fiber. The insertion loss was the difference between the current power ratio for a given fiber and the power ratio obtained during the characterization phase.

Loss (db) = Current power ratio (db) - Initial power ratio (db)

TEST EQUIPMENT:
COMPUTOR 85
DATA ACQUISITION UNIT
DIGITAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS

TEST SAMPLES: #5

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS.
SEE PAGE No. 78

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
INSERTION LOSS	6-23-82	6-23-82
	SPECIFICATION CD 1699	PARAG. 5.2.5
ART NO.	TESTED BY CD 76	TEMP 21.7° R.H. 57%

REQUIREMENT: The insertion loss of a mated pair of connectors each assembled to a length of cable will be measured on an individual optical channel basis. The objective is 1.5 db.

PROCEDURE: The optical transmitter was connected to a dc power source. The transmitter was allowed sufficient time to warm up to operating temperature before any measurements were taken. The reference fiber was connected to the reference port of the optical multimeter. The test fiber was connected to the signal port of the multimeter. The current power ratio (cpr) indicated by the multimeter was recorded. This process was repeated for each of the test fibers in each cable.

PRD (db) = CPR (db) - IPR (db)

TEST EQUIPMENT:

COMPUTOR 85
DATA ACQUISITION UNIT
DIITAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS

TEST SAMPLES: #5

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS.
SEE PAGE No. 106

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
FLEX LIFE	7-9-82	7-15-82
	SPECIFICATION: CD 1699	PARAG.: 6.10
PART NO.	TESTED BY	TEMP 22°C R.H. 68%

REQUIREMENT: With the test connectors setup per Fig. 1, the connector shall be cycled per Paragraph 6.10.3 of CD1699. Monitoring CPR initially and periodically throughout the exposure. These measurements shall not be considered a formal insertion loss measurement, they should be for verifying continuity only. A visual examination shall be performed after each portion of the flex testing is completed, paying particular attention to the cable where it is protected by the connector strain relief.

PROCEDURE: With the test connector installed into a test fixture per Fig. 1, the test connector was then flexed per Fig. 2 for 1000 cycles. At the completion of 1000 cycles the connector was rotated 90° and cycled 1000 times in this axis, after which a visual examination was performed for evidence of deterioration. The test connector and test fixture were installed into a test chamber at 70°c (±2°) for a period of at least 48 hours. The chamber was then programmed to -55°c (±3°) for a period of 48 hours. At the conclusion of the 48 hours and while the connector was still exposed to -55°c, the test connector was subjected to 500 cycles of flex, at the completion of 500 cycles the test connector was rotated 90° and subjected to 500 more cycles. CPR was monitored throughout the complete flex life test.

TEST EQUIPMENT:
COMPUTOR 85
DATA ACQUISITION UNIT
DIGITAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS
FLEX TEST FIXTURE
TEMPERATURE CHAMBER
MICROPROCESSOR

TEST SAMPLES: #5

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
VISUAL EXAMINATION	7-22-82	7-22-82
	SPECIFICATION CD1699	PARAG. 6.1
PART NO.	TESTED BY QAC 4 CD76	TEMP 22.2° R.H. 68%

REQUIREMENTS: When tested per the specification all test samples shall meet the requirements of the applicable documents.

PROCEDURES: The connectors were visually inspected to meet the requirements.

TEST SAMPLES: #5

TEST RESULTS: THE TEST SAMPLE MET THE SPECIFICATION REQUIREMENT.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
INSERTION LOSS	7-22-82	7-22-82
	SPECIFICATION CD 1699	PARAG. 6.2.5
PART NO.	TESTED BY	TEMP 72° R.H. 68%

REQUIREMENT: The insertion loss of a mated pair of connectors each assembled to a length of cable will be measured on an individual optical channel basis. The objective is 1.5 db.

PROCEDURE: The optical transmitter was connected to a dc power source. The transmitter was allowed sufficient time to warm up to operating temperature before any measurements were taken. The reference fiber was connected to the reference port of the optical multimeter. The test fiber was connected to the signal port of the multimeter. The current power ratio (cpr) indicated by the multimeter was recorded. This process was repeated for each of the test fibers in each cable.

PRD (db) = CPR (db) - IPR (db)

TEST EQUIPMENT:

COMPUTOR 85
DATA ACQUISITION UNIT
DITAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS

TEST SAMPLES: #5

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS.
SEE PAGE No. 122

SUBGROUP VI

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
VISUAL EXAMINATION	6-23-82	6-23-82
	SPECIFICATION: CD1699	PARAG.: 6.1
PART NO.	TESTED BY: HAC A CJ76	TEMP: 21.7°C R.H.: 57%

REQUIREMENTS: When tested per the specification all test samples shall meet the requirements of the applicable documents.

PROCEDURES: The connectors were visually inspected to meet the requirements.

TEST SAMPLES: #6

TEST RESULTS: THE TEST SAMPLE MET THE SPECIFICATION REQUIREMENTS.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
BASE LINE INSERTION LOSS	6-23-82	6-23-82
	SPECIFICATION CD 1699	PARAG. 6.2.3.1
PART NO.	TESTED BY	TEMP 21.7° R.H. 52%

REQUIREMENT: Prepare a 20m length of optical cable for each test sample using appropriate preparation techniques.

PROCEDURE: The baseline measurements were performed as follows: The uncut cable and reference fibers were installed on the transmitter for a series of optical power measurements to establish the initial power ratio for each fiber in the cable to the reference fiber. These values form the basis for all subsequent insertion loss readings. After the characterization was completed, the cable was cut and a mating pair of connectors were installed rejoining the original fibers. A new set of optical power ratios were taken to determine the coupling loss for each fiber. The insertion loss was the difference between the current power ratio for a given fiber and the power ratio obtained during the characterization phase.

Loss (db) = Current power ratio (db) - Initial power ratio (db)

TEST EQUIPMENT: COMPUTOR 85, DATA ACQUISITION UNIT, DIGITAL VOLTMETER, POWER SUPPLYS, SOURCE BOXS, DETECTOR BOXS

TEST SAMPLES: #6

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS.
SEE PAGE No. 78

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
INSERTION LOSS	6-23-82	6-23-82
	SPECIFICATION CD 1699	PARAG. 5.2.5
PART NO.	TESTED BY	TEMP 22.7° R.H. 57%

REQUIREMENT: The insertion loss of a mated pair of connectors each assembled to a length of cable will be measured on an individual optical channel basis. The objective is 1.5 db.

PROCEDURE: The optical transmitter was connected to a dc power source. The transmitter was allowed sufficient time to warm up to operating temperature before any measurements were taken. The reference fiber was connected to the reference port of the optical multimeter. The test fiber was connected to the signal port of the multimeter. The current power ratio (cpr) indicated by the multimeter was recorded. This process was repeated for each of the test fibers in each cable.

PRD (db) = CPR (db) - IPR (db)

TEST EQUIPMENT:
COMPUTOR 85
DATA ACQUISITION UNIT
DIITAL VOLTMETER
POWER SUPPLYS
SOURCE BOXS
DETECTOR BOXS

TEST SAMPLES: #6

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS.
SEE PAGE No. 108

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
TWIST	7-20-82	7-20-82
	SPECIFICATION CD1699	PARAG. 6.11
PART NO.	TESTED BY HAC A CD76	TEMP 22°C R.H. 67%

REQUIREMENT: With test connector set up per Fig. 3 CPR measurements shall be taken initially and periodically throughout the cycling, with these measurements taken only to verify optical continuity. At the conclusion of the 1000 twist cycles the cable and cable retaining feature shall be carefully examined for any damage or deterioration.

PROCEDURE: With the test connector setup per Fig. 3, 1000 cycles of twist cycling was completed. The connector and fiber cable were removed from the test fixture and carefully examined for evidence of damage or deterioration of the cable or connector.

TEST EQUIPMENT:
- COMPUTOR 85
- DATA ACQUISITION UNIT
- DIGITAL VOLTMETER
- POWER SUPPLYS
- SOURCE BOXS
- DETECTOR BOXS
- TWIST TEST FIXTURE

TEST SAMPLES: #6

TEST RESULTS: THE TEST SAMPLE MET THE ABOVE STATED REQUIREMENTS.

HUGHES CONNECTING DEVICES

TEST	DATE STARTED	DATE COMPLETED
VISUAL EXAMINATION	7-22-82	7-22-82
	SPECIFICATION: CD1699	PARAG.: 6.1
PART NO.	TESTED BY: QC 76	TEMP: 22°C R.H.: 68%

REQUIREMENTS: When tested per the specification all test samples shall meet the requirements of the applicable documents.

PROCEDURES: The connectors were visually inspected to meet the requirements.

TEST SAMPLES: #6

TEST RESULTS: THE TEST SAMPLE MET THE SPECIFICATION REQUIREMENTS

SAMPLE NO 1
TEST TIME 06 [illegible]

[illegible]
MONITOR VOLTAGE +1.0[illegible]E-001
POWER FACTOR=9[illegible]E-002

CHAN NO	LINK (dB)	FIBER (dB)	CONN (dB)
1	-.[illegible]	-.00	-.[illegible]
2	-1.[illegible]	-.03	-1.[illegible]
3	-1.[illegible]	+.02	-1.[illegible]
4	-1.[illegible]	-.02	-1.[illegible]
5	-1.[illegible]	-.00	-1.[illegible]
6	-.[illegible]	-.03	-.[illegible]

SAMPLE [illegible]
TEST T[illegible]

CURRENT RECORD= [illegible]
MONITOR VOLTAGE +1.[illegible]E-003
POWER FACTOR=[illegible]E-002

CHAN NO	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.[illegible]	-.00	-1.[illegible]
2	-1.33	-.01	-1.33
3	-1.4[illegible]	+.01	-1.30
4	-1.50	-.03	-1.42
5	-1.58	-.05	-1.54
6	-1.38	-.00	-1.38

SAMPLE NO 3
TEST TIME 06:23:09:34:17

CURRENT RECORD= 3
MONITOR VOLTAGE +1.074E-002
POWER FACTOR=91.230E-002

CHAN NO	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.[illegible]	+.01	-1.17
2	-1.30	-.01	-1.3[illegible]
3	-1.19	-.00	-1.16
4	-1.37	-.07	-1.30
5	-1.43	-.06	-1.37
6	-1.62	+.01	-1.63

SAMPLE NO 4
TEST TIME 06:23:09:34:43

CURRENT RECORD= 3
MONITOR VOLTAGE +5.116E-003
POWER FACTOR=75.453E-002

CHAN NO	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.31	-.05	-1.37
2	-1.24	-.00	-1.24
3	-1.00	-.01	-.99
4	-.98	-.00	-.97
5	-1.52	-.05	-1.47
6	-1.55	-.00	-1.56

PRE DURABILITY

SAMPLE NO. 1
TEST TIME 06:24:05:11:35

CURRENT RECORD= 4
MONITOR VOLTAGE +1.118E-002
POWER FACTOR=99.567E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-.90	+.03	-.93
2	-.95	-.01	-.93
3	-1.34	+.03	-1.37
4	-.97	+.04	-1.01
5	-1.73	+.00	-1.[illegible]
6	-1.07	-.01	-1.[illegible]

SAMPLE NO. 2
TEST TIME 06:24:05:11:48

CURRENT RECORD= 4
MONITOR VOLTAGE +1.079E-002
POWER FACTOR=91.723E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.38	+.00	-1.38
2	-1.08	+.02	-1.10
3	-1.38	-.01	-1.37
4	-1.25	-.05	-1.19
5	-1.15	-.04	-1.11
6	-1.92	+.01	-1.93

SAMPLE NO. 3
TEST TIME 06:24:05:12:01

CURRENT RECORD= 4
MONITOR VOLTAGE +2.756E-003
POWER FACTOR=97.039E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.53	-.01	-1.56
2	-1.47	+.03	-1.43
3	-1.51	-.01	-1.52
4	-1.48	+.01	-1.49
5	-1.54	-.05	-1.48
6	-1.53	+.02	-1.51

SAMPLE NO. 4
TEST TIME 06:24:05:12:14

CURRENT RECORD= 4
MONITOR VOLTAGE +5.164E-003
POWER FACTOR=76.159E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.37	+.04	-1.41
2	-1.09	+.00	-1.09
3	-1.53	-.02	-1.51
4	-1.19	+.01	-1.20
5	-1.55	-.04	-1.51
6	-1.63	-.00	-1.63

POST 250 CYCLE DURABILITY

SAMPLE NO 1
TEST TIME 06:24:14:55:39

CURRENT RECORD= 5
MONITOR VOLTAGE +1.106E-002
POWER FACTOR=97.450E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.24	+.01	-1.25
2	-.83	-.03	-.81
3	-1.09	+.03	-1.12
4	-.90	+.03	-.93
5	-1.69	-.00	-1.69
6	-1.28	-.02	-1.26

SAMPLE NO 2
TEST TIME 06:24:14:55:52

CURRENT RECORD= 5
MONITOR VOLTAGE +1.074E-002
POWER FACTOR=91.304E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.63	-.00	-1.62
2	-1.39	+.02	-1.41
3	-1.25	-.01	-1.24
4	-1.17	-.07	-1.11
5	-1.15	-.04	-1.11
6	-1.48	+.02	-1.49

SAMPLE NO 3
TEST TIME 06:24:14:56:05

CURRENT RECORD= 5
MONITOR VOLTAGE +2.753E-003
POWER FACTOR=96.926E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.55	-.01	-1.53
2	-1.50	+.01	-1.51
3	-1.39	+.00	-1.39
4	-1.39	+.00	-1.40
5	-1.66	-.07	-1.59
6	-1.46	+.02	-1.48

SAMPLE NO 4
TEST TIME 06:24:14:56:17

CURRENT RECORD= 5
MONITOR VOLTAGE +5.145E-003
POWER FACTOR=75.880E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.28	+.05	-1.33
2	-1.03	+.01	-1.04
3	-1.05	-.02	-1.03
4	-1.09	-.00	-1.09
5	-1.32	-.04	-1.28
6	-1.75	-.00	-1.75

POST 500 CYCLE DURABILITY

SAMPLE NO 1
TEST TIME 06:25:02:13:29

CURRENT RECORD= 6
MONITOR VOLTAGE +1.110E-002
POWER FACTOR=97.903E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.24	+.03	-1.26
2	-1.25	-.02	-1.23
3	-1.28	+.03	-1.31
4	-1.04	+.03	-1.07
5	-1.29	+.01	-1.29
6	-1.27	-.02	-1.[illegible]

SAMPLE NO 2
TEST TIME 06:25:02:13:42

CURRENT RECORD= 6
MONITOR VOLTAGE +1.071E-002
POWER FACTOR=91.016E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.53	+.00	-1.54
2	-1.15	+.02	-1.17
3	-1.41	-.01	-1.40
4	-1.29	-.07	-1.22
5	-1.15	-.05	-1.10
6	-1.44	+.00	-1.44

SAMPLE NO 3
TEST TIME 06:25:02:13:55

CURRENT RECORD= 6
MONITOR VOLTAGE +2.731E-003
POWER FACTOR=96.175E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.52	-.01	-1.52
2	-1.53	+.03	-1.71
3	-1.38	+.01	-1.38
4	-1.59	-.01	-1.60
5	-1.78	-.06	-1.72
6	-1.53	+.01	-1.54

SAMPLE NO 4
TEST TIME 06:25:02:14:08

CURRENT RECORD= 6
MONITOR VOLTAGE +5.131E-003
POWER FACTOR=75.674E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.34	+.04	-1.38
2	-.91	+.01	-.92
3	-1.71	-.02	-1.69
4	-1.18	-.02	-1.20
5	-1.53	-.04	-1.49
6	-1.72	-.01	-1.72

POST 750 CYCLE DURABILITY

SAMPLE NO. 1
TEST TIME 06:25:10:49:08

CURRENT RECORD= 7
MONITOR VOLTAGE +1.106E-002
POWER FACTOR=97.516E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.34	+.02	-1.36
2	-1.11	-.02	-1.09
3	-1.30	-.03	-1.32
4	-1.38	+.04	-1.42
5	-1.22	+.00	-1.23
6	-1.50	-.02	-1.48

SAMPLE NO. 3
TEST TIME 06:25:10:49:34

CURRENT RECORD= 7
MONITOR VOLTAGE +2.705E-003
POWER FACTOR=95.239E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.50	+.00	-1.50
2	-1.52	+.03	-1.55
3	-1.36	+.01	-1.38
4	-1.58	+.00	-1.59
5	-1.54	-.05	-1.48
6	-1.44	+.01	-1.45

SAMPLE NO. 2
TEST TIME 06:25:10:49:21

CURRENT RECORD= 7
MONITOR VOLTAGE +1.067E-002
POWER FACTOR=90.569E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.64	-.01	-1.63
2	-1.29	+.01	-1.31
3	-1.31	-.01	-1.29
4	-1.19	-.08	-1.11
5	-1.12	-.05	-1.07
6	-1.43	+.00	-1.44

SAMPLE NO. 4
TEST TIME 06:25:10:49:47

CURRENT RECORD= 7
MONITOR VOLTAGE +5.103E-003
POWER FACTOR=75.265E-002

CHAN NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.23	+.05	-1.28
2	-1.25	+.01	-1.26
3	-1.05	-.03	-1.08
4	-1.07	+.01	-1.09
5	-1.34	-.04	-1.30
6	-1.72	-.00	-1.71

POST 1000 CYCLE DURABILITY

SAMPLE NO 1
TEST TIME 06:24:13:20:06

CURRENT RECORD= 4
MONITOR VOLTAGE +1.107E-002
POWER FACTOR=97.520E-002

POST 300 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-.89	+.02	-.91
2	-.85	-.02	-.[illegible]
3	-1.10	+.02	-1.1[illegible]
4	-1.00	-.04	-1.04
5	-1.55	+.00	-1.[illegible]
6	-.96	-.01	-.97

SAMPLE NO 1
TEST TIME 06:24:13:39:00

CURRENT RECORD= 4
MONITOR VOLTAGE +1.106E-002
POWER FACTOR=97.508E-002

POST 350 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-.93	-.01	-.94
2	-.84	-.02	-.83
3	-1.16	+.02	-1.18
4	-1.19	-.03	-1.22
5	-1.55	+.00	-1.[illegible]
6	-1.20	-.02	-1.[illegible]

SAMPLE NO 1
TEST TIME 06:24:13:58:48

CURRENT RECORD= 4
MONITOR VOLTAGE +1.106E-002
POWER FACTOR=97.528E-002

POST 400 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.24	-.02	-1.25
2	-.96	-.03	-.94
3	-1.14	-.03	-1.1[illegible]
4	-1.18	-.03	-1.[illegible]
5	-1.[illegible]	-.00	-1.[illegible]
6	-1.30	-.02	-1.[illegible]

SAMPLE NO 1
TEST TIME 06:24:14:31:03

CURRENT RECORD= 4
MONITOR VOLTAGE -1.109E-002
POWER FACTOR=97.734E-002

POST 450 CYCLES

CHAN. NO	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.24	+.02	-1.26
2	-.95	-.03	-.92
3	-1.17	+.02	-1.19
4	-.97	+.07	-1.00
5	-1.62	-.00	-1.61
6	-1.28	-.02	-1.25

SAMPLE NO 1
TEST TIME 06:24:14:50:17

CURRENT RECORD= 4
MONITOR VOLTAGE +1.107E-002
POWER FACTOR=97.550E-002

POST 500 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.24	-.02	-1.26
2	-.83	-.02	-.81
3	-1.08	+.03	-1.12
4	-.89	+.03	-.93
5	-1.69	-.00	-1.62
6	-1.28	-.02	-1.26

SAMPLE NO. 1
TEST TIME 06:24:15:14:20

CURRENT RECORD= 5
MONITOR VOLTAGE -1.107E-002
POWER FACTOR=97.555E-002

POST 550 CYCLES

CHAN NO	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.24	-.02	[illegible]
2	-.89	-.01	[illegible]
3	-1.10	+.03	[illegible]
4	-.93	-.04	[illegible]
5	-1.75	-.01	[illegible]
6	-1.25	-.01	-1.24

SAMPLE NO 1
TEST TIME 06:24:15:51:50

CURRENT RECORD= 5
MONITOR VOLTAGE +1.108E-002
POWER FACTOR=97.583E-002

POST 600 CYCLES

CHAN NO.	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.18	+.02	-1.20
2	-1.00	-.02	-.98
3	-1.12	+.02	-1.15
4	-.90	+.03	-.92
5	-1.35	-.00	-1.35
6	-.97	-.02	-.95

SAMPLE NO 1
TEST TIME 06:24:16:10:53

CURRENT RECORD= 5
MONITOR VOLTAGE +1.111E-002
POWER FACTOR=97.965E-002

POST 650 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.13	+.02	-1.15
2	-.96	-.02	-.94
3	-1.15	+.02	-1.17
4	-.87	+.03	-.90
5	-1.52	-.00	-1.52
6	-1.01	-.02	-.99

SAMPLE NO 1
TEST TIME 06:24:16:36:45

CURRENT RECORD= 5
MONITOR VOLTAGE +1.109E-002
POWER FACTOR=97.721E-002

POST 700 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.13	-.02	-1.15
2	-2.33	-.03	[illegible]
3	-1.15	-.03	[illegible]
4	-.88	-.03	[illegible]
5	-1.71	-.00	[illegible]
6	-1.00	-.02	-.98

READING TAKEN
BEFORE CLEANING

SAMPLE NO 1
TEST TIME 06:24:13:29:53

CURRENT RECORD= 5
MONITOR VOLTAGE +1.112E-002
POWER FACTOR=99.017E-002

CHAN NO	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.33	-.02	-1.31
2	-1.25	-.02	-1.23
3	-1.27	-.01	-1.28
4	-1.03	-.03	-1.07
5	-1.28	-.00	-1.30
6	-1.27	-.02	-1.25

POST 750 CYCLES

SAMPLE NO 1
TEST TIME 06:25:08:44:03

CURRENT RECORD= 6
MONITOR VOLTAGE +1.112E-002
POWER FACTOR=98 033E-002

CHAN. NO	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.17	-.02	-1.19
2	-1.28	-.02	-1.26
3	-1.17	-.02	-1.19
4	-.98	-.03	-1.02
5	-1.66	-.00	-1.67
6	-1.36	-.01	-1.34

POST 800 CYCLES

SAMPLE NO 1
TEST TIME 06:25:09:00:15

CURRENT RECORD= 6
MONITOR VOLTAGE +1.111E-002
POWER FACTOR=97 892E-002

POST 850 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.16	-.02	-1.18
2	-1.35	-.02	-1.34
3	-1.19	-.02	-1.21
4	-.97	-.04	-1.01
5	-1.65	-.01	-1.70
6	-1.33	-.01	-1.32

SAMPLE NO. 1
TEST TIME 06:25:09:41:04

CURRENT RECORD= 6
MONITOR VOLTAGE +1.109E-002
POWER FACTOR=97.727E-003

POST 900 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.16	-.02	-1.18
2	-1.11	-.02	-1.09
3	-1.19	+.03	-1.22
4	-1.27	+.04	-1.31
5	-1.55	-.01	-1.56
6	-1.35	-.01	-1.33

SAMPLE NO. 1
TEST TIME 06:25:10:01:09

CURRENT RECORD= 6
MONITOR VOLTAGE +1.106E-002
POWER FACTOR=97.579E-003

POST 950 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.21	-.02	-1.23
2	-1.33	-.02	-1.30
3	-1.20	+.02	-1.22
4	-.97	-.03	-1.01
5	-1.41	+.00	-1.41
6	-1.34	-.02	-1.32

SAMPLE NO. 1
TEST TIME 06:25:10:35:37

CURRENT RECORD= 6
MONITOR VOLTAGE +1.107E-002
POWER FACTOR=97.510E-003

POST 1000 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.25	-.03	-1.26
2	-1.40	-.02	-1.37
3	-1.21	-.01	-1.24
4	-1.00	-.03	-1.03
5	-1.30	-.00	-1.30
6	-1.45	-.02	-1.44

SAMPLE NO. 2
TEST TIME 06:24:10:30:03

CURRENT RECORD= 4
MONITOR VOLTAGE -1.074E-002
POWER FACTOR=91.298E-002

POST 300 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.46	-.01	-1.45
2	-1.20	+.01	-1.21
3	-1.33	-.01	-1.32
4	-1.33	-.07	-1.27
5	-1.17	-.05	-1.12
6	-1.93	+.01	-1.94

SAMPLE NO. 2
TEST TIME 06:24:10:56:07

CURRENT RECORD= 4
MONITOR VOLTAGE +1.075E-002
POWER FACTOR=91.343E-002

POST 350 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	[illegible]	-.01	-1.57
2	[illegible]	+.01	-1.36
3	-1.32	-.01	-1.32
4	-1.28	-.07	[illegible]
5	-1.30	-.05	-1.25
6	-1.92	+.01	-1.93

SAMPLE NO. 2
TEST TIME 06:24:12:34:33

CURRENT RECORD= 4
MONITOR VOLTAGE +1.075E-002
POWER FACTOR=91.353E-002

POST 400 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.60	-.00	[illegible]
2	-1.32	+.01	-1.34
3	-1.22	-.01	[illegible]
4	-1.18	-.07	[illegible]
5	-1.25	-.05	-1.20
6	-1.55	-.01	-1.55

SAMPLE NO 3
TEST TIME 06:24:12:54:51

CURRENT RECORD= 4
MONITOR VOLTAGE +1.075E-002
POWER FACTOR=91.325E-002

POST 450 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.54	-.00	-1.53
2	-1.36	+.01	-1.37
3	-1.26	-.01	-1.25
4	-1.18	-.07	-1.11
5	-1.25	-.04	-1.21
6	-1.51	+.01	-1.51

SAMPLE NO 3
TEST TIME 06:24:13:16:18

CURRENT RECORD= 4
MONITOR VOLTAGE +1.076E-002
POWER FACTOR=91.434E-002

POST 500 CYCLES

CHAN. NO	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.63	-.00	-1.63
2	-1.38	+.02	-1.40
3	-1.24	-.01	-1.23
4	-1.15	-.07	-1.09
5	-1.14	-.04	-1.09
6	-1.46	+.01	-1.47

SAMPLE NO 3
TEST TIME 06:24:16:11:06

CURRENT RECORD= 5
MONITOR VOLTAGE +1.075E-002
POWER FACTOR=91.355E-002

POST 550 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.48	-.00	-1.48
2	-1.14	-.01	-1.16
3	-1.31	-.01	-1.30
4	-1.24	-.08	[illegible]
5	-1.15	-.05	[illegible]
6	-1.55	-.00	[illegible]

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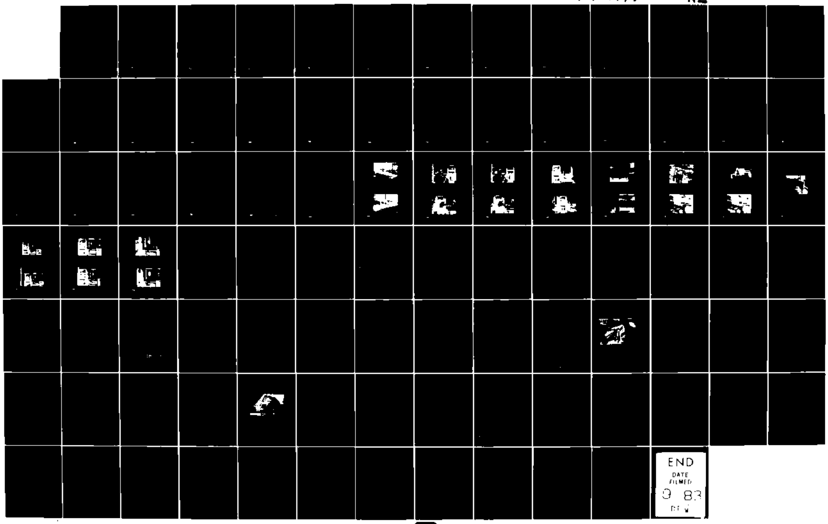

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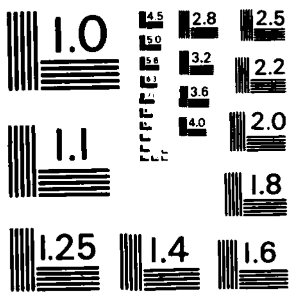
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5.0
5.6

SAMPLE NO 2
TEST TIME 06:24:15:36:58

CURRENT RECORD= 5
MONITOR VOLTAGE -1.073E-003
POWER FACTOR=91.169E-002

CHAN NO	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.42	-.00	-1.42
2	-1.06	-.02	-1.08
3	-1.38	-.01	-1.37
4	-1.21	-.07	-1.14
5	-1.10	-.04	-1.06
6	-1.51	+.01	-1.52

POST 600 CYCLES

SAMPLE NO 2
TEST TIME 06:24:17:05:17

CURRENT RECORD= 5
MONITOR VOLTAGE -1.073E-003
POWER FACTOR=91.177E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.47	+.00	-1.47
2	-1.06	+.02	-1.08
3	-1.43	-.01	-1.42
4	-1.25	-.07	-1.18
5	-1.09	-.04	-1.05
6	-1.45	+.01	-1.46

POST 650 CYCLES

SAMPLE NO 2
TEST TIME 06:24:17:38:57

CURRENT RECORD= 5
MONITOR VOLTAGE -1.074E-003
POWER FACTOR=91.227E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.52	-.01	-1.52
2	-1.10	-.01	-1.11
3	-1.38	-.01	-1.38
4	-1.30	-.08	-1.22
5	-1.11	-.05	-1.06
6	-1.47	-.00	-1.47

POST 700 CYCLES

SAMPLE NO. 1
TEST TIME 06:24:18:30:12

CURRENT RECORD= 5
MONITOR VOLTAGE -1.073E-002
POWER FACTOR=91.149E-002

POST 750 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.54	-.01	-1.53
2	-1.15	+.01	-1.16
3	-1.40	-.01	-1.39
4	-1.27	-.09	-1.18
5	-1.13	-.06	-1.07
6	-1.43	-.01	-1.41

SAMPLE NO 2
TEST TIME 06:25:07:42:34

CURRENT RECORD= 6
MONITOR VOLTAGE +1.069E-002
POWER FACTOR=90.875E-002

POST 800 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.61	-.00	-1.61
2	-1.28	+.02	-1.30
3	-1.32	-.01	-1.30
4	-1.21	-.07	-1.14
5	-1.13	-.05	-1.09
6	-1.40	+.01	-1.41

SAMPLE NO 3
TEST TIME 06:25:08:00:43

CURRENT RECORD= 6
MONITOR VOLTAGE +1.069E-002
POWER FACTOR=90.869E-002

POST 850 CYCLES

CHAN NO.	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.67	+.00	-1.67
2	-1.25	+.02	-1.28
3	-1.29	-.01	-1.28
4	-1.18	-.07	-1.11
5	-1.14	-.04	-1.10
6	-1.39	+.02	-1.41

SAMPLE NO. 2
TEST TIME 06:25:08:31:13

CURRENT RECORD= 6
MONITOR VOLTAGE +1.063E-002
POWER FACTOR=90.854E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.79	+.00	-1.79
2	-1.37	+.02	-1.39
3	-1.29	-.01	-1.28
4	-1.18	-.07	-1.11
5	-1.17	-.04	-1.13
6	-1.45	+.01	-1.46

POST 900 CYCLES

SAMPLE NO. 2
TEST TIME 06:25:09:00:27

CURRENT RECORD= 6
MONITOR VOLTAGE +1.063E-002
POWER FACTOR=90.833E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.59	+.00	-1.59
2	-1.37	+.02	-1.39
3	-1.31	-.01	-1.31
4	-1.17	-.07	-1.10
5	-1.19	-.04	-1.15
6	-1.44	-.00	-1.44

POST 950 CYCLES

SAMPLE NO. 2
TEST TIME 06:25:09:41:17

CURRENT RECORD= 6
MONITOR VOLTAGE +1.063E-002
POWER FACTOR=90.801E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.63	-.00	-1.63
2	-1.53	+.01	-1.54
3	-1.30	-.01	-1.29
4	-1.15	-.07	-1.07
5	-1.13	-.04	-1.08
6	-1.43	+.01	-1.44

POST 1000 CYCLES

SAMPLE NO. 3
TEST TIME 06 24:10:13:42

CURRENT RECORD= 4
MONITOR VOLTAGE +2.745E-003
POWER FACTOR=96.558E-002

POST 300 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.49	+.01	-1.50
2	-1.39	+.02	-1.40
3	-1.53	+.01	-1.53
4	-1.41	-.01	-1.42
5	-1.57	-.06	-1.51
6	-1.47	+.02	-1.49

SAMPLE NO. 3
TEST TIME 06:24:10:51:22

CURRENT RECORD= 4
MONITOR VOLTAGE +2.747E-003
POWER FACTOR=96.722E-002

POST 350 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.48	-.00	-1.48
2	-1.52	+.01	-1.53
3	-1.23	+.01	-1.24
4	-1.45	+.00	-1.45
5	-1.91	-.07	-1.84
6	-1.45	-.00	-1.45

SAMPLE NO. 3
TEST TIME 06:24:11:15:44

CURRENT RECORD= 4
MONITOR VOLTAGE +2.755E-003
POWER FACTOR=97.004E-003

POST 400 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.49	-.02	-1.47
2	-1.55	+.01	-1.57
3	-1.35	-.00	-1.35
4	-1.45	-.00	-1.45
5	-1.85	-.07	-1.78
6	-1.45	-.00	-1.45

SAMPLE NO. 3
TEST TIME 06:24:12:37:25

CURRENT RECORD= 4
MONITOR VOLTAGE +2.743E-003
POWER FACTOR=96.570E-002

POST 450 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.50	-.00	-1.50
2	-1.53	-.02	-1.52
3	-1.32	-.01	-1.33
4	-1.33	+.01	-1.41
5	-1.70	-.06	-1.64
6	-1.44	+.02	-1.46

SAMPLE NO. 3
TEST TIME 06:24:12:55:03

CURRENT RECORD= 4
MONITOR VOLTAGE +2.748E-003
POWER FACTOR=96.746E-002

POST 500 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.52	+.00	-1.52
2	-1.49	+.02	-1.50
3	-1.36	+.00	-1.36
4	-1.40	+.01	-1.41
5	-1.66	-.06	-1.60
6	-1.45	+.02	-1.46

SAMPLE NO. 3
TEST TIME 06:24:22:56:19

CURRENT RECORD= 5
MONITOR VOLTAGE +2.741E-003
POWER FACTOR=96.528E-002

POST 550 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.51	-.01	-1.50
2	-1.55	+.01	-1.57
3	-1.38	-.01	-1.38
4	-1.41	+.00	-1.41
5	-1.75	-.08	-1.58
6	-1.47	-.00	-1.47

SAMPLE NO. 3
TEST TIME 06:25:00:16:29

CURRENT RECORD= 5
MONITOR VOLTAGE +2.734E-003
POWER FACTOR=96.254E-002

POST 600 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.58	-.00	-1.58
2	-1.40	+.01	-1.42
3	-1.46	+.00	-1.47
4	-1.49	+.01	-1.50
5	-1.63	-.06	-1.58
6	-1.48	-.01	-1.48

SAMPLE NO. 3
TEST TIME 06:25:00:40:37

CURRENT RECORD= 5
MONITOR VOLTAGE +2.730E-003
POWER FACTOR=96.134E-002

POST 650 CYCLES

CHAN NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.58	-.00	-1.58
2	-1.47	+.02	-1.50
3	-1.40	+.01	-1.41
4	-1.54	+.01	-1.54
5	-1.77	-.05	-1.71
6	-1.46	+.01	-1.47

SAMPLE NO. 3
TEST TIME 06:25:01:48:05

CURRENT RECORD= 5
MONITOR VOLTAGE -2.735E-003
POWER FACTOR=96.296E-002

POST 700 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.56	-.01	-1.55
2	-1.44	+.02	-1.46
3	-1.36	+.00	-1.36
4	-1.55	-.01	-1.56
5	-1.63	-.06	-1.53
6	-1.55	+.00	-1.55

SAMPLE NO 3
TEST TIME 06:25:02:09 29

CURRENT RECORD= 5
MONITOR VOLTAGE +2.734E-003
POWER FACTOR=96.278E-002

POST 750 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.53	-.01	-1.52
2	-1.57	+.02	-1.70
3	-1.37	-.00	-1.37
4	-1.58	+.00	-1.59
5	-1.77	-.06	-1.71
6	-1.53	+.01	-1.55

SAMPLE NO 3
TEST TIME 06:25:05:36:56

CURRENT RECORD= 6
MONITOR VOLTAGE +2.716E-003
POWER FACTOR=95.516E-002

POST 800 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.52	-.00	-1.52
2	-1.55	+.03	-1.58
3	-1.39	+.01	-1.40
4	-1.54	+.02	-1.56
5	-1.95	-.05	-1.91
6	-1.55	+.02	-1.57

SAMPLE NO 3
TEST TIME 06:25:06:14:25

CURRENT RECORD= 6
MONITOR VOLTAGE +2.719E-003
POWER FACTOR=95.732E-002

POST 850 CYCLES

CHAN. NO	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.54	+.00	-1.54
2	-1.51	+.03	-1.64
3	-1.41	-.00	-1.42
4	-1.57	+.02	-1.59
5	-1.71	-.06	-1.65
6	-1.51	-.01	-1.52

SAMPLE NO. 3
TEST TIME 06:25:06:32:21

CURRENT RECORD= 6
MONITOR VOLTAGE -2.717E-003
POWER FACTOR=95.673E-002

POST 900 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.56	-.01	-1.56
2	-1.59	+.03	-1.61
3	-1.47	+.00	-1.47
4	-1.53	-.02	-1.55
5	-1.53	-.06	-1.47
6	-1.45	+.02	-1.47

SAMPLE NO. 3
TEST TIME 06:25:06:49:23

CURRENT RECORD= 6
MONITOR VOLTAGE -2.719E-003
POWER FACTOR=95.732E-002

POST 950 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.57	-.01	-1.57
2	-1.61	+.02	-1.63
3	-1.47	+.01	-1.47
4	-1.59	+.02	-1.60
5	-1.55	-.06	-1.49
6	-1.47	+.02	-1.49

SAMPLE NO. 3
TEST TIME 06:25:07:15:04

CURRENT RECORD= 6
MONITOR VOLTAGE -2.716E-003
POWER FACTOR=95.644E-002

POST 1000 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.34	-.01	-1.33
2	-1.55	+.02	-1.58
3	-1.43	+.01	-1.44
4	-1.56	+.02	-1.58
5	-1.73	-.05	-1.68
6	-1.45	-.02	-1.47

SAMPLE NO 4
TEST TIME 06:24:07:54:57

CURRENT RECORD= 4
MONITOR VOLTAGE -5.143E-003
POWER FACTOR=75.852E-002

POST 300 CYCLES

CHAN. NO	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.29	+.05	-1.34
2	-1.16	+.01	-1.17
3	[illegible]	-.01	-1.09
4	[illegible]	+.00	[illegible]
5	-1.30	-.04	[illegible]
6	-1.74	-.00	-1.74

SAMPLE NO 4
TEST TIME 06:24:08:23:25

CURRENT RECORD= 4
MONITOR VOLTAGE +5.143E-003
POWER FACTOR=75.922E-002

POST 350 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.31	+.05	-1.35
2	-1.09	+.01	-1.10
3	-.98	-.02	-.96
4	-1.14	-.01	-1.14
5	-1.70	-.04	-1.66
6	-1.78	-.00	-1.73

SAMPLE NO. 4
TEST TIME 06:24:09:36:37

CURRENT RECORD= 4
MONITOR VOLTAGE +5.138E-003
POWER FACTOR=75.771E-002

POST 400 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.29	+.06	-1.35
2	-1.01	-.01	-1.01
3	-1.08	-.02	-1.06
4	-1.08	-.00	-1.08
5	-1.33	-.05	[illegible]
6	-1.73	-.01	[illegible]

SAMPLE NO. 4
TEST TIME 0[illegible] 14:10:12:55

CURRENT RECORD= 4
MONITOR VOLTAGE +5.133E-003
POWER FACTOR=75.779E-002

POST 450 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.22	-.05	-1.[illegible]
2	-1.02	-.01	-1.03
3	-1.07	-.01	-1.08
4	-1.08	+.00	-1.09
5	-1.35	-.04	-1.31
6	-1.74	-.01	-1.73

SAMPLE NO. 4
TEST TIME 06:24:22:56:32

CURRENT RECORD= 5
MONITOR VOLTAGE +5.122E-003
POWER FACTOR=75.543E-002

POST 500 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.15	+.05	-1.20
2	-.80	+.01	-.81
3	-1.16	-.01	-1.15
4	-1.24	-.01	-1.23
5	-2.38	-.04	-2.34
6	-1.43	-.00	-1.43

SAMPLE NO. 4
TEST TIME 06:24:23:02:17

CURRENT RECORD= 5
MONITOR VOLTAGE +5.124E-003
POWER FACTOR=75.568E-002

POST 550 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.15	+.05	-1.20
2	-.81	-.01	-.82
3	-1.26	-.02	-1.24
4	-1.39	+.01	-1.40
5	-1.56	-.04	-1.52
6	-1.48	-.01	-1.47

SAMPLE NO. 4
TEST TIME 06:25:00:16:42

CURRENT RECORD= 5
MONITOR VOLTAGE +5.121E-003
POWER FACTOR=75.527E-002

CHAN NO.	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.25	+.05	-1.29
2	-.88	+.01	-.89
3	-1.53	-.02	-1.51
4	-1.36	-.00	-1.36
5	-1.53	-.04	-1.49
6	-1.72	-.01	-1.72

POST 600 CYCLES

SAMPLE NO. 4
TEST TIME 06:25:00:40:50

CURRENT RECORD= 5
MONITOR VOLTAGE +5.125E-003
POWER FACTOR=75.584E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.24	+.05	-1.29
2	-.97	+.01	-.99
3	-1.68	-.02	-1.66
4	-1.32	-.01	-1.31
5	-1.57	-.04	-1.53
6	-1.73	-.00	-1.72

POST 650 CYCLES

SAMPLE NO. 4
TEST TIME 06:25:01:48:18

CURRENT RECORD= 5
MONITOR VOLTAGE +5.132E-003
POWER FACTOR=75.695E-002

CHAN NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.71	+.04	-1.36
2	-.81	-.01	[illegible]
3	-1.62	-.02	-1.55
4	-1.04	+.02	-1.06
5	-1.55	-.04	[illegible]
6	-1.58	-.01	[illegible]

POST 700 CYCLES

SAMPLE NO 4
TEST TIME 06:25:03:09:42

CURRENT RECORD= 5
MONITOR VOLTAGE +5.137E-003
POWER FACTOR=75.757E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.33	+.04	-1.37
2	-.91	+.00	-.93
3	-1.70	-.03	-1.67
4	-1.18	-.03	-1.15
5	-1.52	-.04	-1.47
6	-1.72	-.01	-1.71

POST 750 CYCLES

SAMPLE NO 4
TEST TIME 06:25:05:37:09

CURRENT RECORD= 6
MONITOR VOLTAGE +5.118E-003
POWER FACTOR=75.485E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.25	+.04	-1.29
2	-.99	+.01	-1.00
3	-1.16	-.02	-1.14
4	-1.10	-.00	-1.10
5	-1.05	-.04	-1.01
6	-1.73	-.01	-1.73

POST 800 CYCLES

SAMPLE NO 4
TEST TIME 06:25:06:14:37

CURRENT RECORD= 6
MONITOR VOLTAGE +5.124E-003
POWER FACTOR=75.565E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.21	-.04	-1.25
2	-1.00	+.01	-1.01
3	-1.16	-.02	-1.14
4	-1.13	-.01	-1.12
5	-1.60	-.04	-1.56
6	-1.74	-.00	-1.74

POST 850 CYCLES

SAMPLE NO. 4
TEST TIME 06:25:06:32:34

CURRENT RECORD= 6
MONITOR VOLTAGE +5.120E-003
POWER FACTOR=75.510E-002

POST 900 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.24	+.04	-1.28
2	-1.00	-.01	-1.01
3	-1.22	-.02	-1.20
4	-1.09	+.00	-1.09
5	-1.35	-.04	-1.31
6	-1.71	-.00	-1.71

SAMPLE NO. 4
TEST TIME 06:25:07:15:17

CURRENT RECORD= 6
MONITOR VOLTAGE +5.119E-003
POWER FACTOR=75.500E-002

POST 950 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.23	+.05	-1.28
2	-1.00	-.01	-1.01
3	-1.29	-.02	-1.28
4	-1.12	-.01	-1.11
5	-1.56	-.04	-1.52
6	-1.75	-.00	-1.75

SAMPLE NO. 4
TEST TIME 06:25:07:43:00

CURRENT RECORD= 6
MONITOR VOLTAGE +5.123E-003
POWER FACTOR=75.552E-002

POST 1000 CYCLES

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.22	+.05	-1.27
2	-1.00	+.01	-1.01
3	-1.15	-.02	-1.14
4	-1.05	-.01	-1.05
5	[illegible]	-.04	[illegible]
6	[illegible]	.01	[illegible]

SAMPLE NO 1
TEST TIME 06 25 14 10 50

CURRENT RECORD= 2
MONITOR VOLTAGE -1 [illegible]E-003
POWER FACTOR=96 [illegible]E-002

CHAN NO	LINK (dB)	FIBER (dB)	CONN (dB)
1	- .51	- .00	- .5[illegible]
2	-1.[illegible]	- .03	-1.0[illegible]
3	-1.[illegible]	- .03	-1.[illegible]4
4	-1.25	- .03	-1.37
5	-1.[illegible]	- .00	- .[illegible]
6	- .93	- .01	

SAMPLE NO 3
TEST TIME 06 25 14 11 15

CURRENT RECORD= 9
MONITOR VOLTAGE -2 [illegible]45E-003
POWER FACTOR=96 537E-002

CHAN NO	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.51	- .00	-1.[illegible]
2	-1.[illegible]	- .02	-1.[illegible]
3	-1.43	- .01	-1.[illegible]
4	-1.50	- .03	-1.[illegible]
5	-1.5[illegible]	- .0[illegible]	-1.[illegible]
6	-1.50	- .00	-1.[illegible]

PRE IMMERSION

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```
SAMPLE NO [illegible]
TEST TIME 06 [illegible] 05 [illegible]

CURRENT RECORD= 10
MONITOR VOLTAGE -1.[illegible]E-002
POWER FACTOR=96.[illegible]E-002

CHAN.    LINK     FIBER    CONN
 NO      (dB)     (dB)     (dB)

 1      -1.[illegible]    -.01    -1.[illegible]
 2      -.[illegible]     -.02    -.[illegible]4
 3      -[illegible]      -.03    -[illegible]4
 4      -.84      -.04    -.80
 5      -1.[illegible]    -.02    -1.[illegible]
 6      -.[illegible]4    -.01    -.[illegible]4
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SAMPLE NO  3
TEST TIME 06:28:05:33:35

CURRENT RECORD= 10
MONITOR VOLTAGE +2.664E-003
POWER FACTOR=93.806E-002

CHAN.    LINK     FIBER    CONN.
 NO.     (dB)     (dB)     (dB)

 1      -2.85     +.00    -2.85
 2      -1.21     +.05    -1.26
 3      -.[illegible]     -.07    -.[illegible]
 4      -1.94     -.05    -1.99
 5      -1.85     -.02    -1.83
 6      -1.45     -.02    -1.47
```

POST IMMERSION

SAMPLE NO 3
TEST TIME 07 09 12 48 39

CURRENT RECORD= 11
MONITOR VOLTAGE -2.553E-007
POWER FACTOR=10.305E-001

CHAN. NO	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.54	+.05	-1.59
2	-1.11	+.09	-1.[illegible]
3	-1.45	+.07	-1.[illegible]
4	-1.53	+.09	-1.[illegible]
5	-1.19	+.03	-1.[illegible]
6	-1.71	+.11	-1.82

SAMPLE NO 3
TEST TIME 07:09:12:49:05

CURRENT RECORD= 12
MONITOR VOLTAGE +3.453E-003
POWER FACTOR=10.125E-001

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.00	-.01	-.99
2	-1.20	-.12	-1.08
3	-1.30	-.05	-1.24
4	-1.51	-.05	-1.46
5	-1.25	-.05	-1.20
6	-1.11	-.05	-1.[illegible]

PRE FLEX

SAMPLE NO. 3
TEST TIME 07:15:10:35:03

CURRENT RECORD= 13
MONITOR VOLTAGE +3.551E-003
POWER FACTOR=83.817E-003

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.43	+.00	-1.44
2	-1.11	+.06	-1.17
3	-1.38	+.03	-1.41
4	-1.28	-.07	-1.35
5	-1.13	-.00	-1.13
6	-1.54	+.04	-1.58

SAMPLE NO. 5
TEST TIME 07:15:10:35:33

CURRENT RECORD= 13
MONITOR VOLTAGE +3.465E-003
POWER FACTOR=10.218E-001

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.00	-.00	-1.00
2	-1.13	-.15	-.37
3	-1.30	-.06	-1.24
4	-1.37	-.07	-1.30
5	-1.22	-.08	-1.14
6	-1.12	-.07	-1.05

POST FLEX

SAMPLE NO. 4
TEST TIME 07:13 10:46:51

CURRENT RECORD= 14
MONITOR VOLTAGE +5.056E-007
POWER FACTOR=74.740E-003

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.13	-.00	-1.13
2	-1.05	-.03	-1.02
3	-1.10	-.02	-1.08
4	-.98	-.04	-1.02
5	-.85	-.02	-.84
6	-1.54	-.01	-1.55

SAMPLE NO. 5
TEST TIME 07:19:10:47:17

CURRENT RECORD= 14
MONITOR VOLTAGE +2.512E-003
POWER FACTOR=86.073E-003

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-.88	-.01	-.89
2	-1.05	-.11	-1.16
3	-.84	-.05	-.78
4	-1.04	-.08	-1.13
5	-.73	-.01	-.86
6	[illegible]	-.01	-.74

PRE TWIST

SAMPLE NO 4
TEST TIME 07 20:10:24:31

CURRENT RECORD= 15
MONITOR VOLTAGE +4.351E-003
POWER FACTOR=73.013E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.33	+.01	-1.34
2	-.88	+.02	-.91
3	-1.13	-.02	-1.18
4	-1.17	+.02	-1.20
5	-.89	-.02	-.91
6	-1.53	-.01	-1.52

SAMPLE NO 5
TEST TIME 07:20:10:24:57

CURRENT RECORD= 15
MONITOR VOLTAGE +2.388E-003
POWER FACTOR=81.825E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN (dB)
1	-.85	-.07	-.92
2	-.99	-.11	-1.11
3	-.78	-.03	-.81
4	-1.05	+.05	-1.11
5	-.73	-.05	-.78
6	-.74	-.05	-.79

POST TWIST

SAMPLE NO. 1
TEST TIME 07:21:15:08:23

CURRENT RECORD= 15
MONITOR VOLTAGE +9.131E-003
POWER FACTOR=80.482E-003

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.81	+.15	-1.96
2	-.73	+.10	-.83
3	-.99	+.07	-1.06
4	-1.45	+.19	-1.64
5	-1.77	+.17	-1.93
6	-1.49	+.15	-1.65

CABLE RETENTION @ 400 Lb.
NO. 1 PLUG

SAMPLE NO 1
TEST TIME 07:21:15:13:51

CURRENT RECORD= 16
MONITOR VOLTAGE -9.1075E-003
POWER FACTOR=80.3708E-003

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.81	+.17	-1.95
2	-.71	-.09	-.90
3	-.95	-.07	-1.02
4	-1.36	+.18	-1.53
5	-1.73	-.15	-1.88
6	-1.45	+.15	-1.31

POST CABLE RETENTION
No. 1 PLUG

SAMPLE NO 1
TEST TIME 07:22:08:19:38

CURRENT RECORD= 16
MONITOR VOLTAGE +7.829E-003
POWER FACTOR=69.006E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.80	+.14	-1.94
2	-.74	-.10	-.83
3	-.78	+.09	-.86
4	-1.70	+.19	-1.88
5	-1.75	+.17	-1.92
6	-1.56	+.16	-1.71

CABLE RETENTION @ 400 Lb.
No. 1 REC.

SAMPLE NO. 1
TEST TIME 07:22:08:25:28

CURRENT RECORD= 17
MONITOR VOLTAGE +7.835E-003
POWER FACTOR=69.064E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.79	-.14	-1.93
2	-.72	+.09	-.81
3	-.77	+.08	-.85
4	-1.67	+.19	-1.86
5	-1.72	-.16	-1.89
6	-1.54	+.15	-1.69

POST CABLE RETENTION
No. 1 REC.

SAMPLE NO 2
TEST TIME 07:22:08:57:08

CURRENT RECORD= 17
MONITOR VOLTAGE +9.753E-003
POWER FACTOR=82.873E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.57	+.05	-1.62
2	-.78	+.02	-.79
3	-1.28	-.03	-1.25
4	-1.37	-.11	-1.26
5	-1.03	-.02	-1.01
6	-1.64	+.04	-1.68

CABLE RETENTION @ 400 Lb.
NO. 2 PLUG

SAMPLE NO. 2
TEST TIME 07:22:09:02:36

CURRENT RECORD= 18
MONITOR VOLTAGE -9.749E-003
POWER FACTOR=82.844E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.55	+.05	-1.59
2	-.74	+.02	-.75
3	-1.21	-.04	-1.18
4	-1.37	-.12	-1.25
5	-1.02	-.02	-1.00
6	-1.52	-.02	-1.53

POST CABLE RETENTION
No. 2 PLUG

SAMPLE NO 2
TEST TIME 07:22:09:54:01

CURRENT RECORD= 18
MONITOR VOLTAGE +9.724E-003
POWER FACTOR=92.628E-002

CHAN. NO	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.38	+.05	-1.43
2	-.74	+.01	-.75
3	-1.24	-.04	-1.21
4	-1.47	-.12	-1.34
5	-1.02	-.04	-.98
6	-1.38	-.00	-1.38

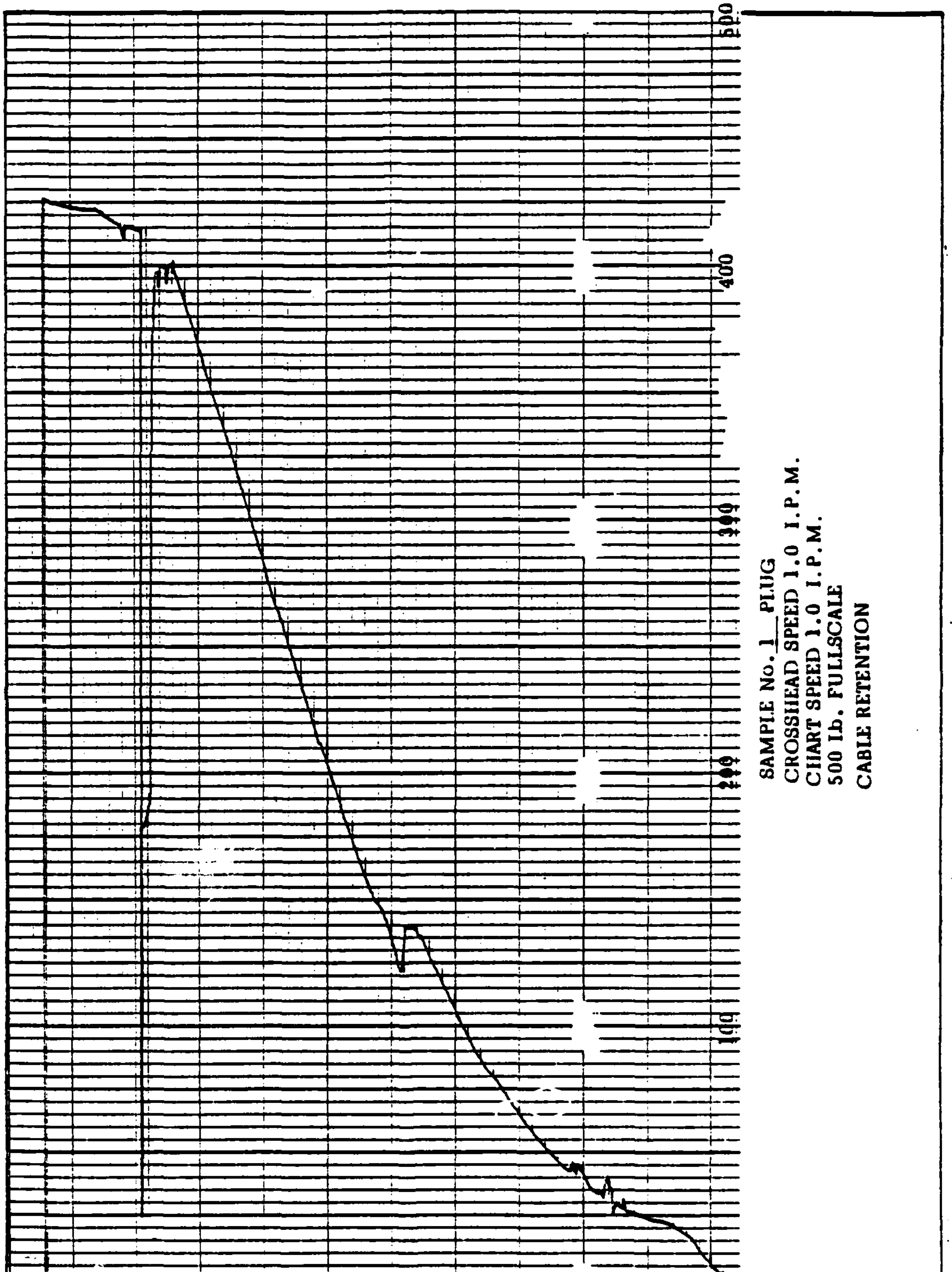
CABLE RETENTION @ 400 Lb.
No. 2 REC.

SAMPLE NO 2
TEST TIME 07:22:10:01:57

CURRENT RECORD= 19
MONITOR VOLTAGE +9.725E-003
POWER FACTOR=82.635E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.35	-.05	-1.40
2	-.73	+.01	-.74
3	-1.22	-.04	-1.18
4	-1.44	-.13	-1.31
5	-1.00	-.03	-.96
6	-1.36	+.02	-1.38

POST CABLE RETENTION
No. 2 REC.



HUGHES Connecting Devices

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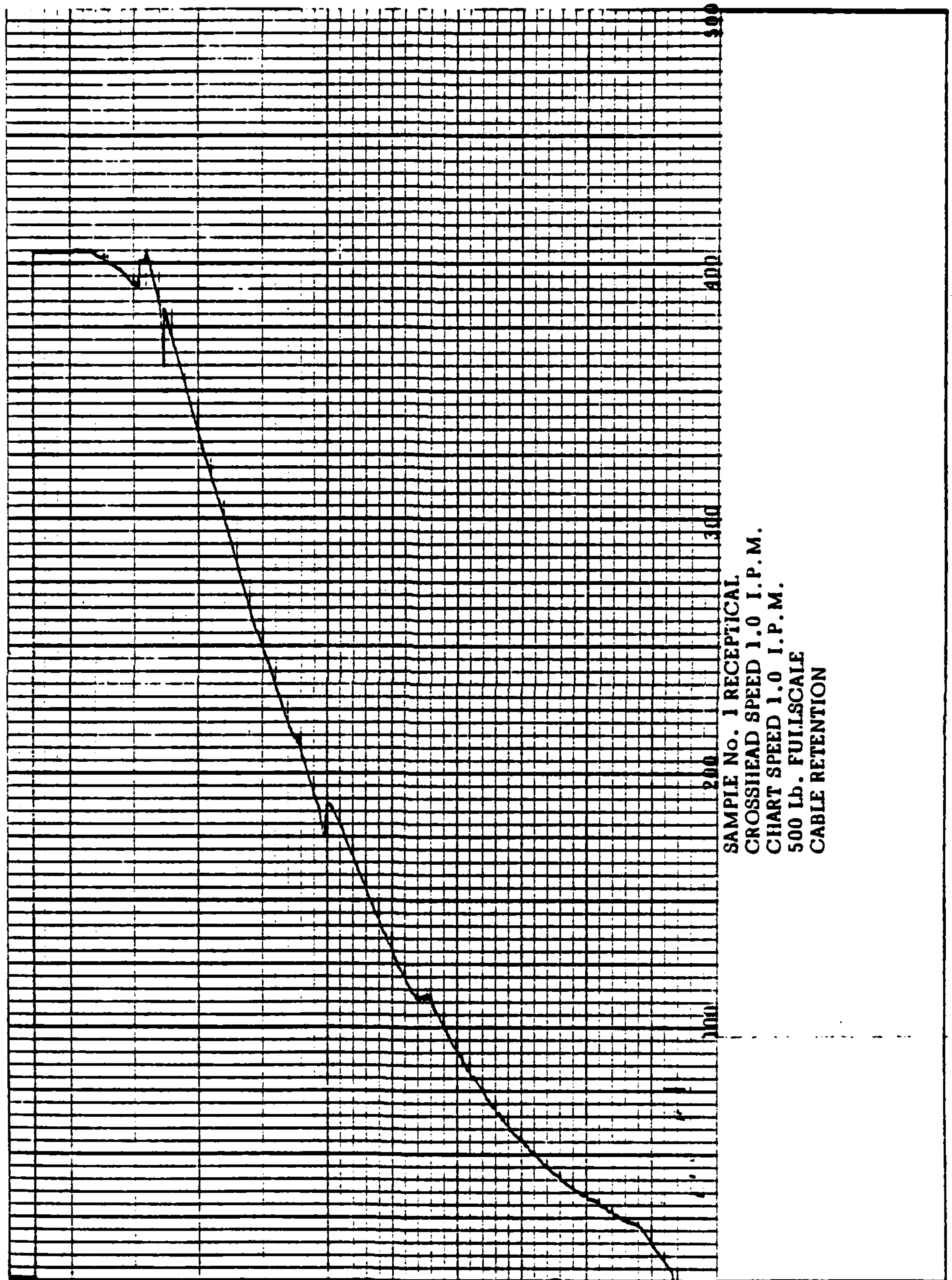

HUGHES Connecting Devices

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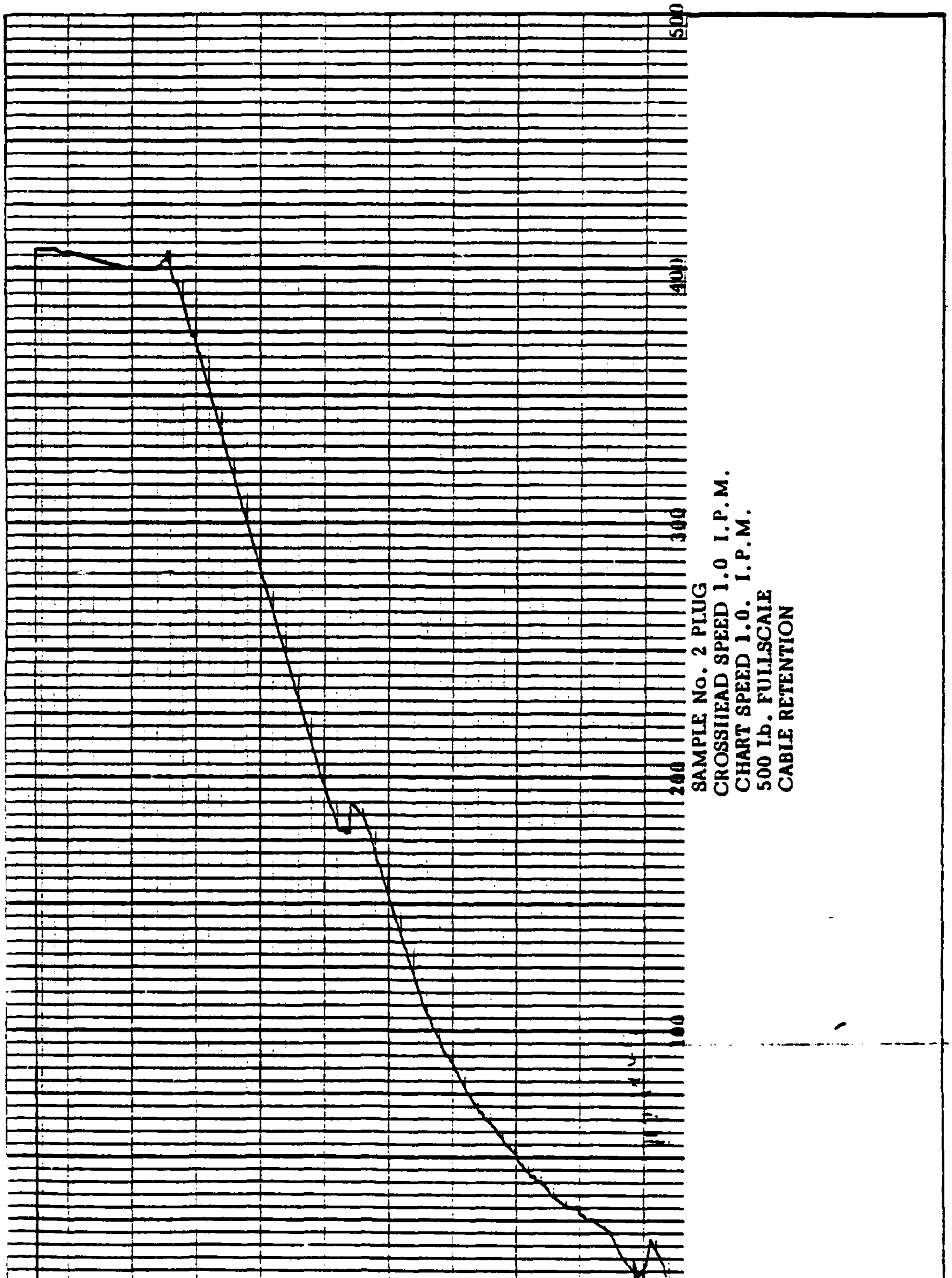
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400
300
200
100
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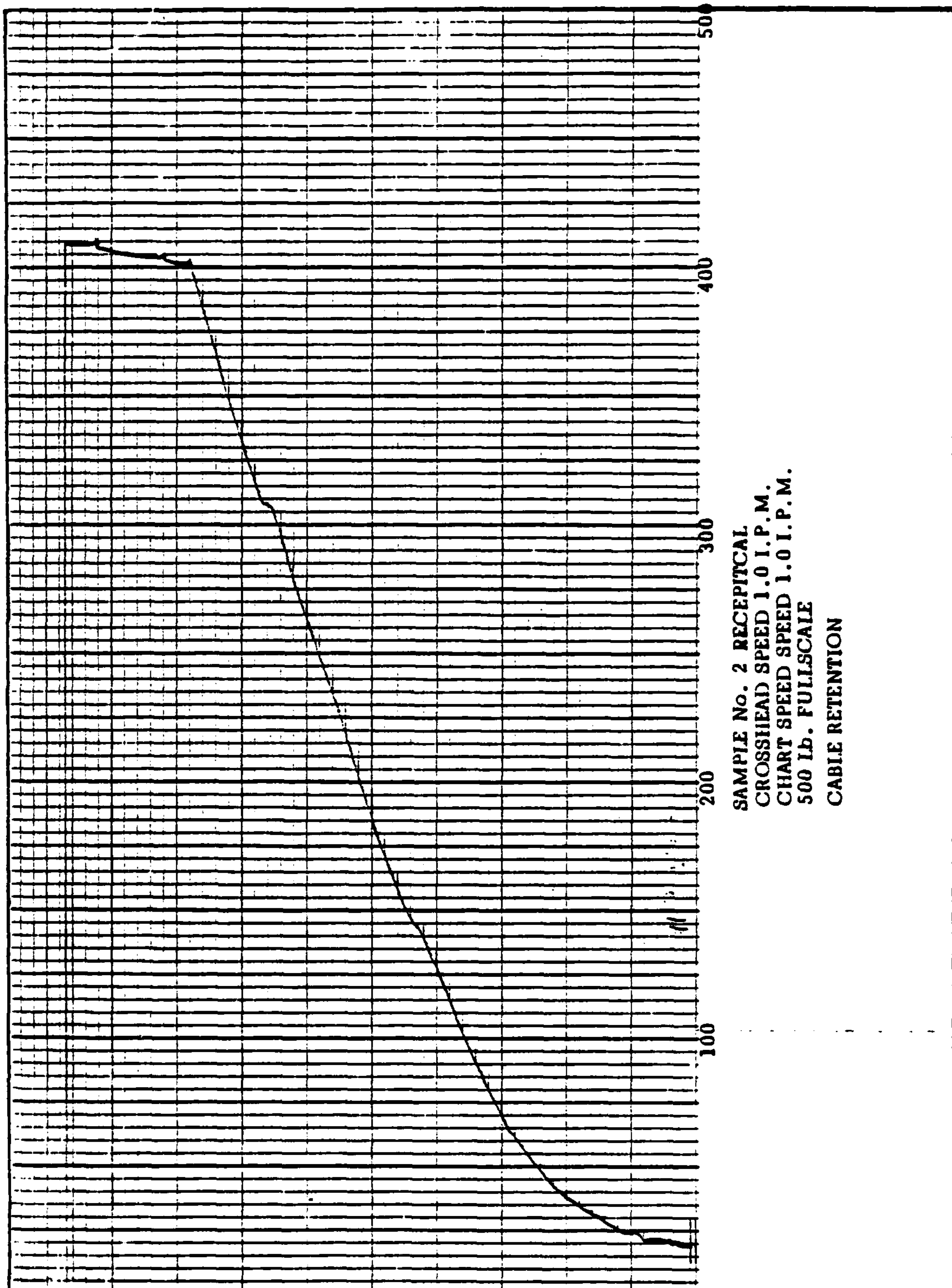
CHART SPEED 1.0. I.P.M.
500 Lb. FULLSCALE
CABLE RETENTION



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SAMPLE NO. 1
TEST TIME 07:22:10:17:11

CURRENT RECORD= 20
MONITOR VOLTAGE +7.779E-003
POWER FACTOR=68.569E-002

CHAN NO	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.78	+.15	-1.93
2	-.83	+.10	-.93
3	-1.56	+.09	-1.64
4	-1.55	-.13	-1.84
5	-1.77	+.18	-1.94
6	-1.58	+.15	-1.74

SAMPLE NO. 2
TEST TIME 07:22:10:17:23

CURRENT RECORD= 20
MONITOR VOLTAGE +9.717E-003
POWER FACTOR=82.567E-002

CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.42	+.04	-1.47
2	-.72	+.01	-.73
3	-1.22	-.04	-1.18
4	-1.44	-.12	-1.32
5	-.99	-.02	-.97
6	-1.45	+.03	-1.48

SAMPLE NO. 3
TEST TIME 07:22:10:17:36

CURRENT RECORD= 20
MONITOR VOLTAGE +2.439E-003
POWER FACTOR=85.863E-002

CHAN NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.35	+.07	-1.42
2	-1.08	+.10	-1.18
3	-1.34	+.08	-1.43
4	-1.22	+.08	-1.30
5	-1.09	+.03	-1.12
6	-1.52	+.11	-1.63

SAMPLE NO. 4
TEST TIME 07:22:10:17:49

CURRENT RECORD= 20
MONITOR VOLTAGE -4.895E-003
POWER FACTOR=72.195E-002

CHAN. NO	LINK (dB)	FIBER (dB)	CONN (dB)
1	-1.33	+.02	-1.35
2	-.89	+.02	-.91
3	-1.15	-.01	-1.14
4	-1.17	+.00	-1.17
5	-.75	-.03	-.73
6	-1.63	-.01	-1.62

SAMPLE NO. 5
TEST TIME 07:22:10:18:02

CURRENT RECORD= 20
MONITOR VOLTAGE +3.505E-003
POWER FACTOR=10.278E-001

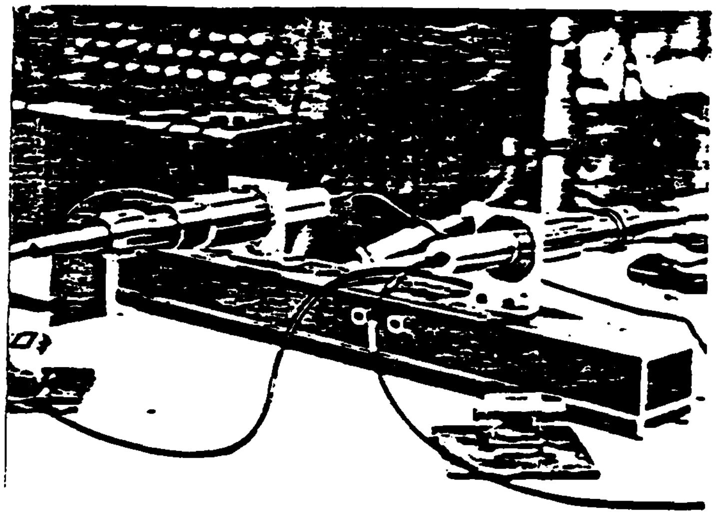
CHAN. NO	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-1.10	-.05	-1.05
2	-1.19	-.17	-1.02
3	-1.31	-.06	-1.25
4	-1.42	-.09	-1.33
5	-1.25	-.11	-1.15
6	-1.20	-.12	-1.09

SAMPLE NO. 6
TEST TIME 07:22:10:18:15

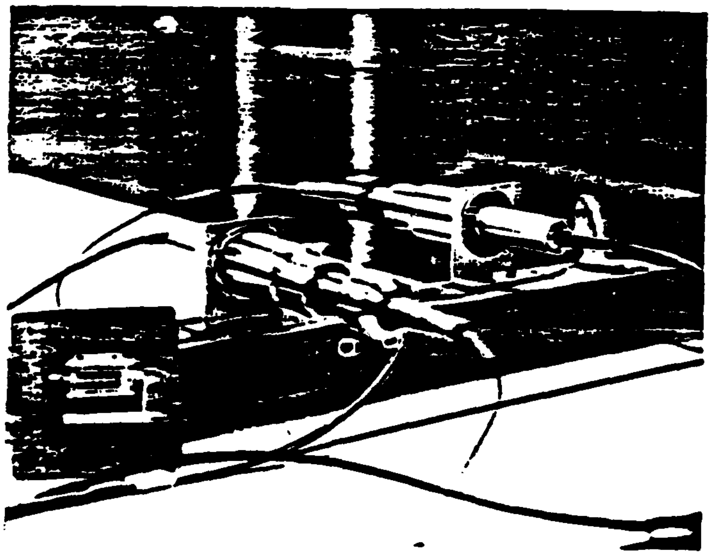
CURRENT RECORD= 20
MONITOR VOLTAGE +2.343E-003
POWER FACTOR=80.262E-002

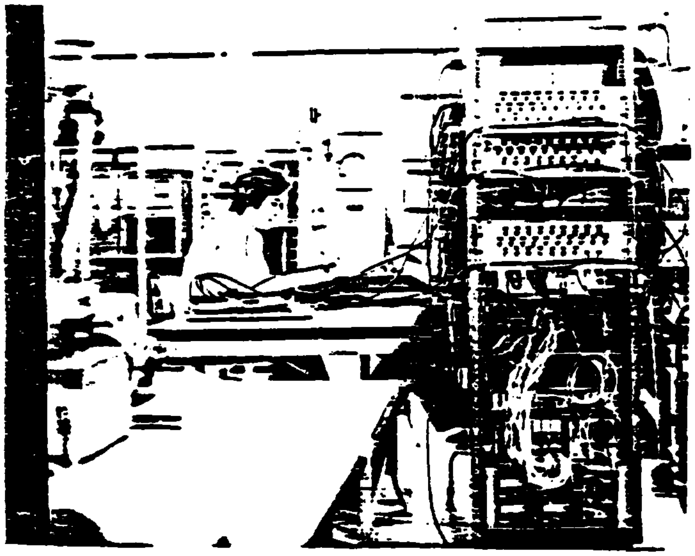
CHAN. NO.	LINK (dB)	FIBER (dB)	CONN. (dB)
1	-.78	+.08	-.86
2	-.97	+.15	-1.13
3	-.82	+.05	-.87
4	-1.07	+.08	-1.15
5	-.76	+.07	-.83
6	-.88	+.07	-.94

FINAL INSERTION LOSS FOR
ALL TEST SAMPLES

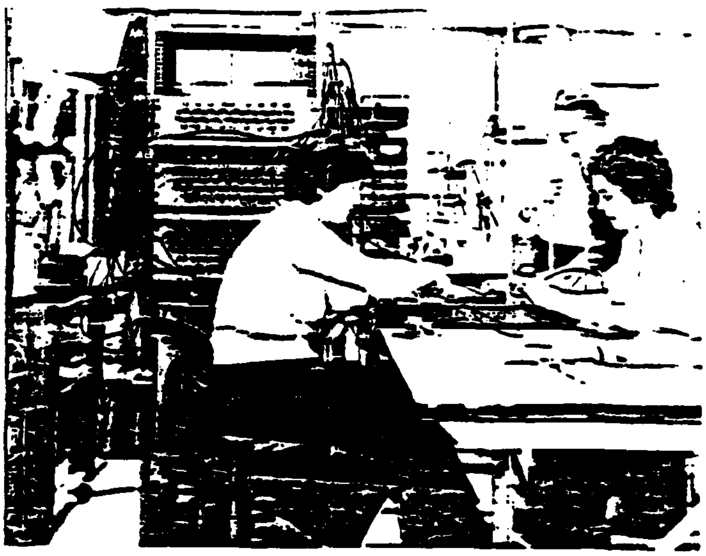


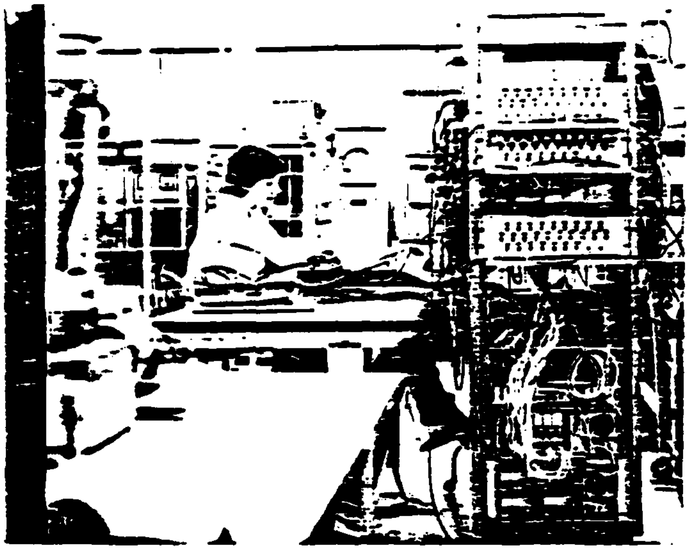
DURABILITY TEST SETUP



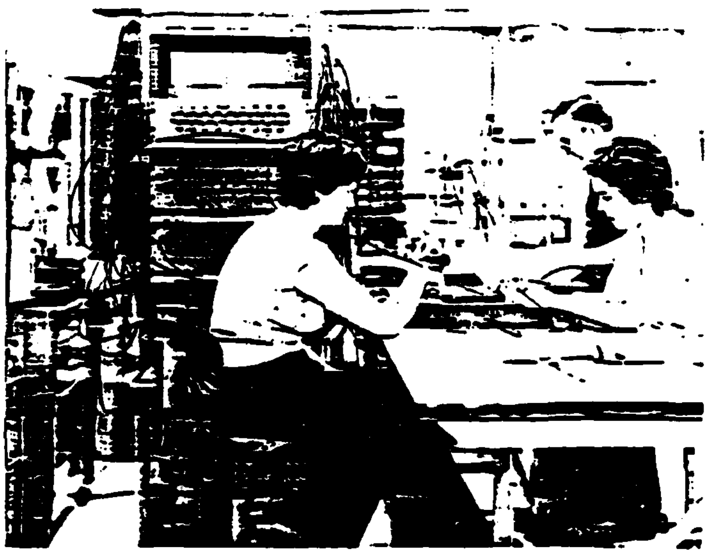


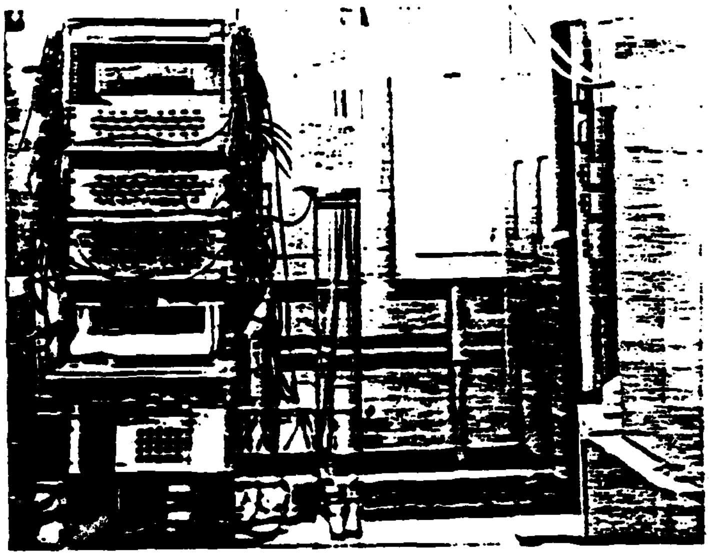
DURABILITY TESTING



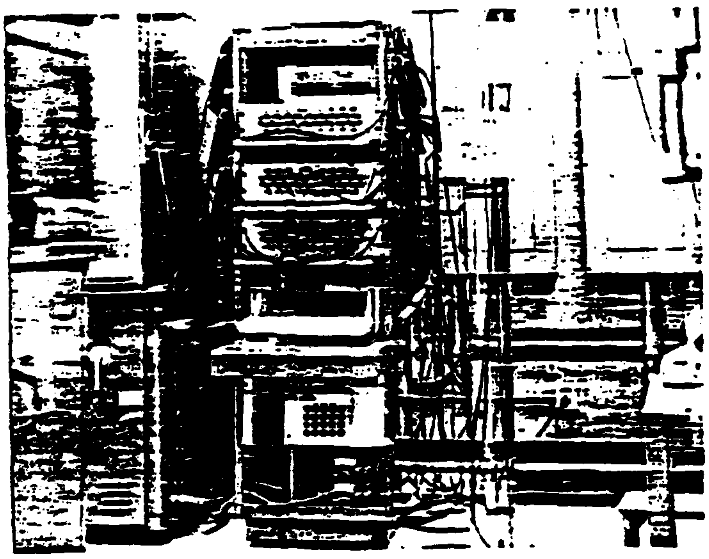


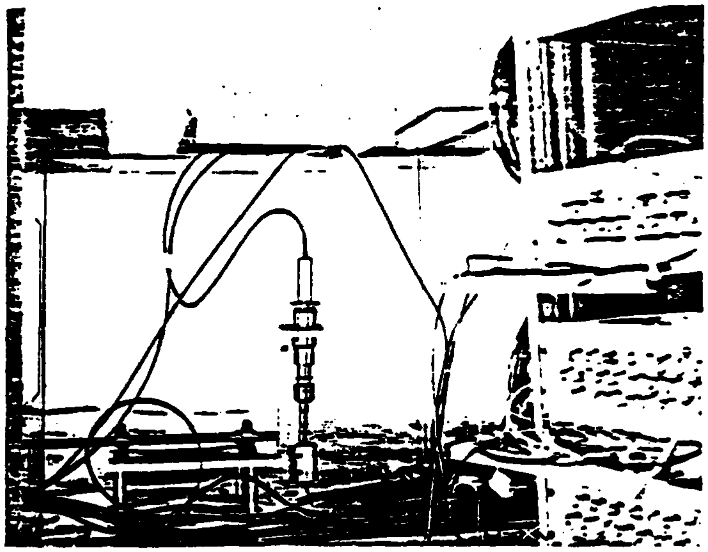
DURABILITY TESTING



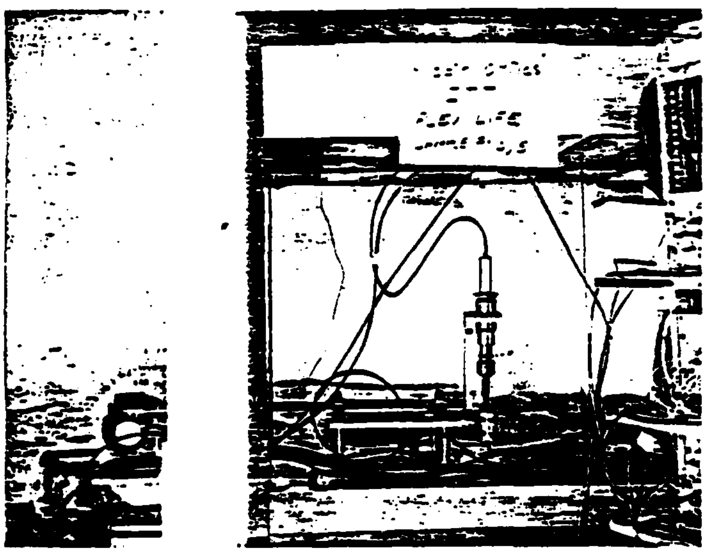


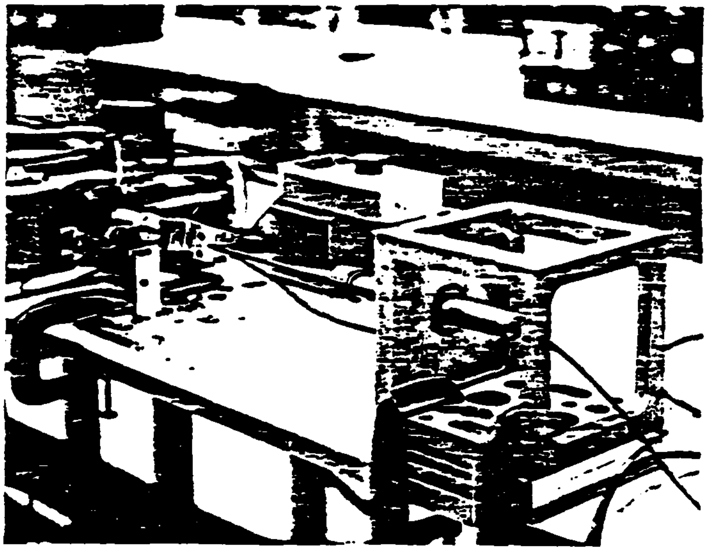
IMMERTION TEST SETUP



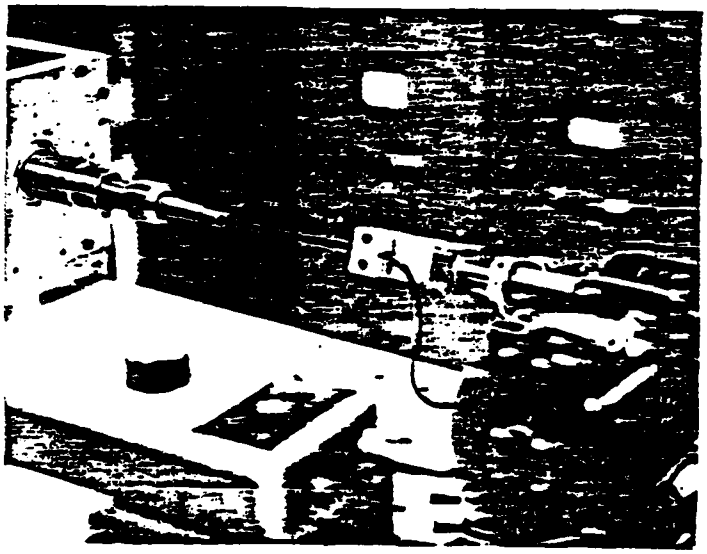


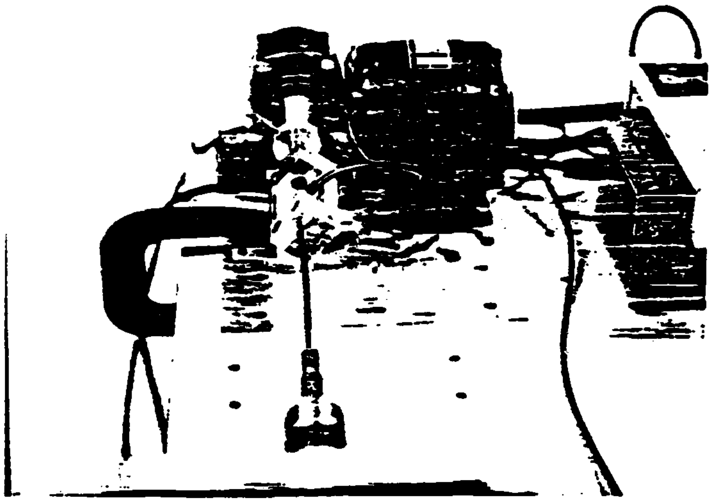
FLEX TEST SETUP





TWIST TEST SETUP





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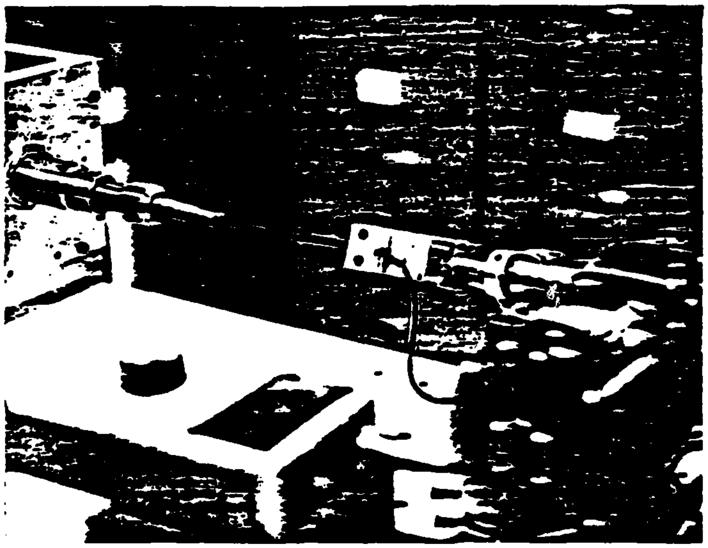
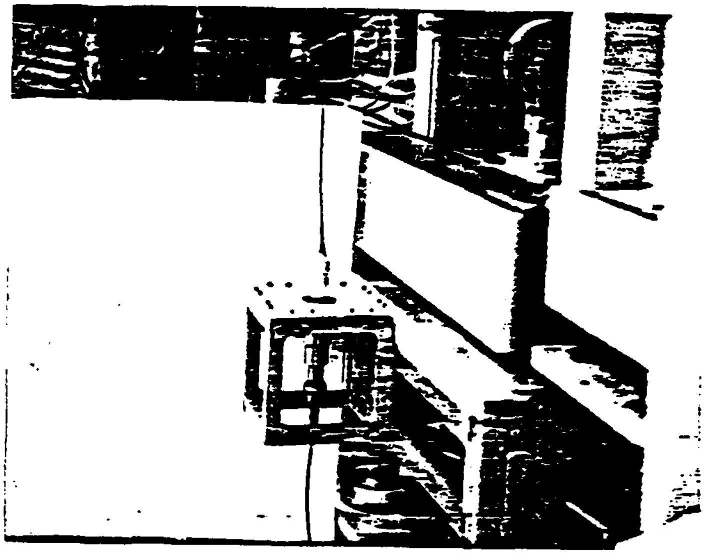
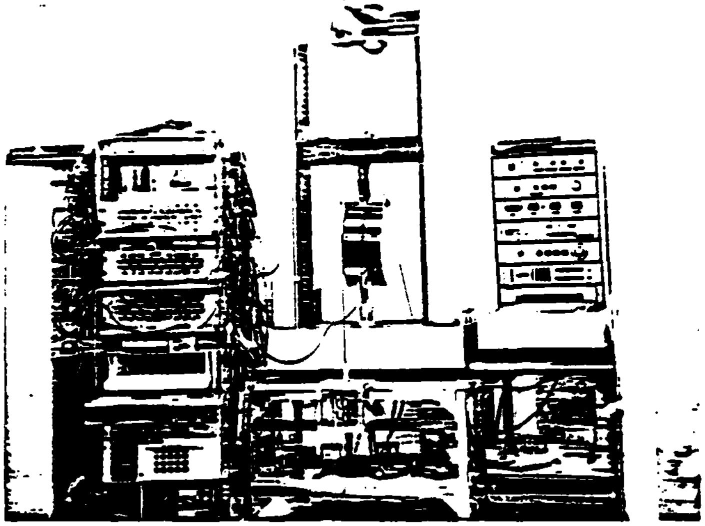




CABLE RETENTION TEST SETUP



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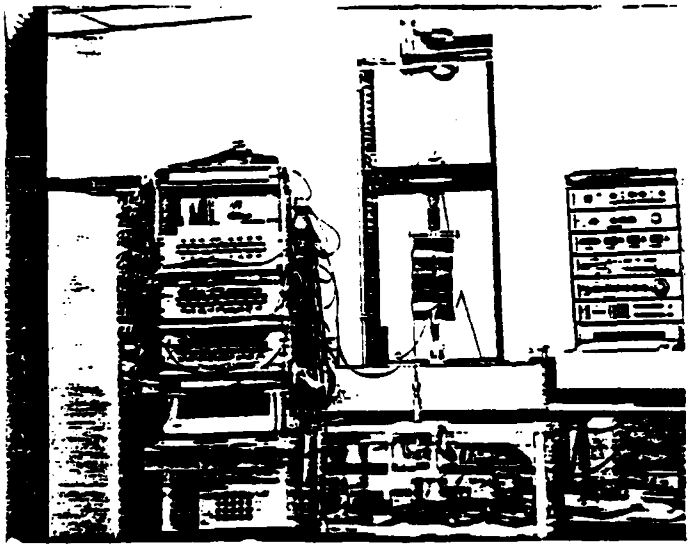
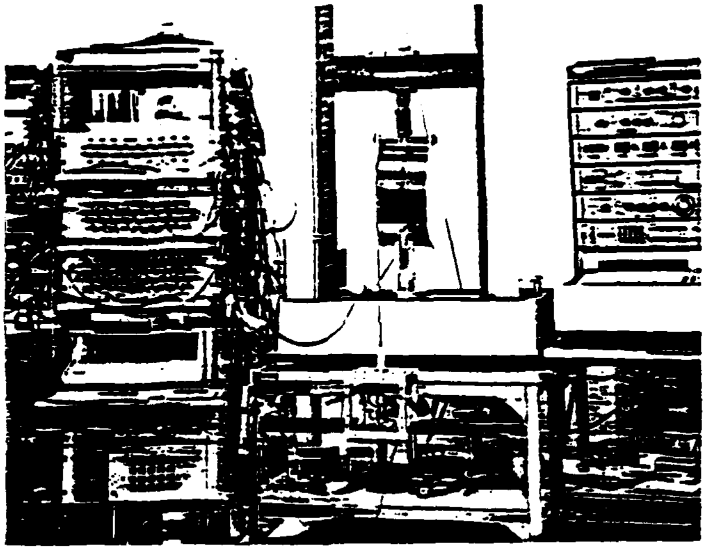
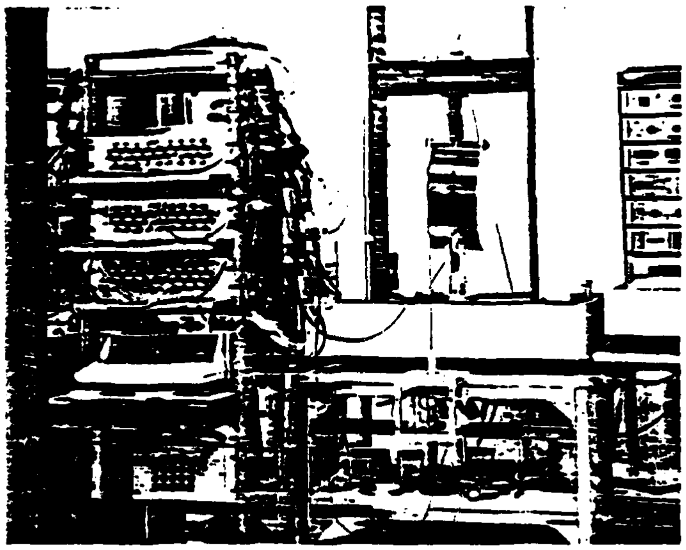
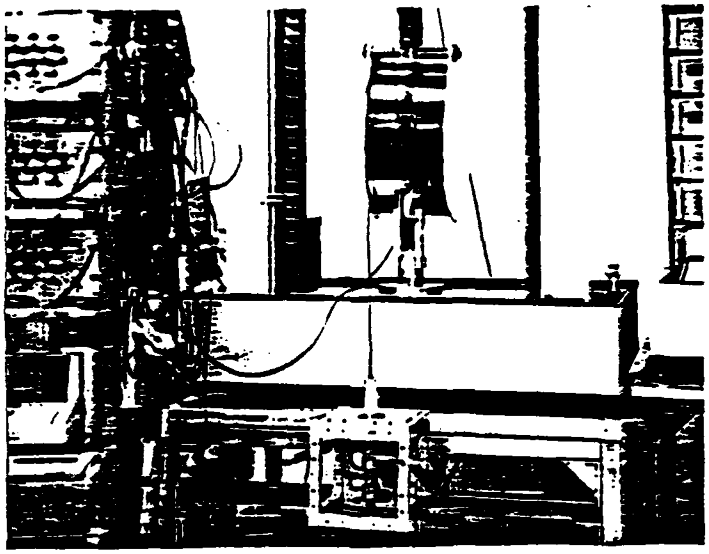


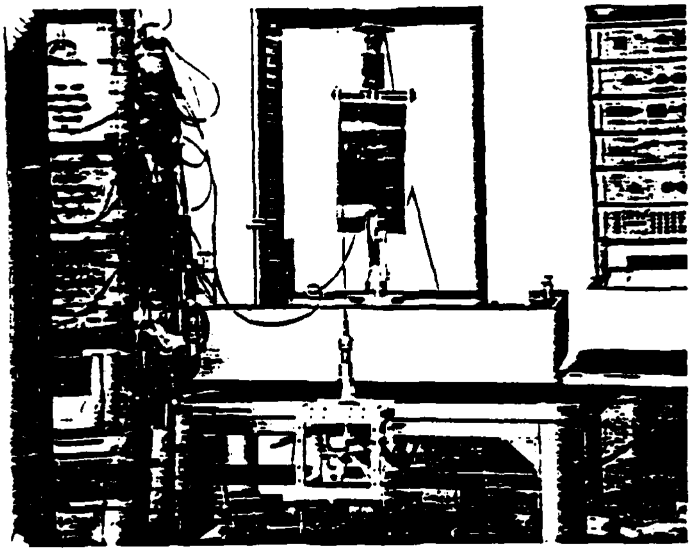


CABLE RETENTION TEST SETUP





CABLE RETENTION TEST SETUP



APPENDIX C

TECHNICAL GUIDELINES

FOR ULTRA LOW LOSS

OPTICAL FIBER CABLE ASSEMBLIES

ATTACHMENT 3 Appendix C

Technical Guidelines

"Ultra Low Loss Optical Fiber Cable Assemblies"

1. SCOPE:

1.1 These guidelines cover the development of ultra low-loss optical fiber cable assemblies and bulkhead receptacles for use in tactical Time Division Multiplex (TDM) communication systems for distances ranging from one to eight kilometers without repeaters. Operation will be at selected wavelengths from 6000 to 10600 Angstroms for both analog and data transmission with data rates to 20 megabits per second per kilometer. Each cable assembly will consist of a one-kilometer length of cable terminated at each end with a hermaphroditic connector (identical connectors mate with each other). The mating faces of the connectors must be optical with minimal coupling loss and crosstalk to provide efficient connection of up to eight assemblies in tandem. The cable assemblies must be rugged to withstand a wide range of environmental and mechanical exposures typical of tactical field applications.

2. APPLICABLE DOCUMENTS:

2.1 The following documents of the issue in effect on date of invitation for bid form a part of this specification:

Specifications:

Military:

MIL-C-13777	Cable, Special, Purpose, Electrical: General Specification For
MIL-I-3930	Insulating and Jacketing Compounds Electrical (For Cable, Cords, and Wires)
MIL-C-55583	Cable Assembly, Special Purpose, Electrical CX-11230( )/G and Cable Assembly Adapter CX-10734( )/G
MIL-M-24041	Molding and Potting Compound, Chemically Cured, Polyurethane (Polyether-based)
MIL-D-1000	Drawings, Engineering and Associated Lists
MIL-R-3241	Reels, Cable (Reels DR-5( ), DR-7( ), DR-8( ), RC-453( )/G, RL-159( )/U)

Federal:

L-P-390	Plastic, Molding Material, Polyethylene, Low and Medium Density
L-P-389	Fluorinated Ethylene Propylene, Fluorocarbon, Molding and Extrusion Materials
L-P-403	Polytetrafluoroethylene and Fluorocarbon Plastic, Molding, and Extrusion Materials
L-P-394	Plastic Molding Material (Propylene, Plastics, Injection and Extrusion)

Standards:

Military:

MIL-STD-202	Test Methods for Electronic and Electrical Component Parts
MIL-STD-446	Environments for Electronic Parts, Tubes, and Solid State Devices
MIL-STD-461	Electromagnetic Interference Characteristics Requirements for Equipment
MIL-STD-810	Environmental Test Methods

3. Technical Objectives:

3.1 Background:

An optical fiber communications cable has been developed under Contract DAAB07-73-C-0348 with Corning Glass Works. The cable, which is currently being marketed by Corning under the trade name, Corguide, has attenuation under 20 dB/km at discrete wavelengths in the region of 6,000 to 10,600 Angstroms. It represents a significant first step in the development of fiber optic cables which have been optimized for tactical field applications. However, the cable is not satisfactory for data transmission at 20 Mb/sec over 8-kilometer TDM links without repeaters. The cable incorporates fibers with a step index profile which causes unacceptable pulse broadening at the prescribed data rates and transmission distance. Furthermore, the attenuation is too high to permit acceptable transmission over the 8-kilometer link. It is an objective of this procurement to develop an optical fiber cable with graded index profile fibers and attenuation low enough to satisfy the intended system's requirements. Since this program will culminate in the delivery of cable assemblies, connectors will be required for termination of the cable at both ends. Consequently, another

e of this procurement is to develop a ruggediz d, environment re- hermaphroditic connector to be used for this purpose. The final e of this procurement is to develop a bulkhead receptacle for use nal equipment and shelters.

Objectives:

The objectives will be directed toward achieving the optimum cable configuration consistent with the program objectives. The cable will be comprised of a six element fiber optic cable terminated able multicontact connectors. The program will be conducted in ses, namely, a Cable Phase and a Connector/Cable Assembly Phase.

.1 Cable Phase: The approach for achieving the optimum cable design nclude, but not necessarily be limited to the following:

.1.1 Investigation of core and dopant materials, processes, and ues for fabricating multimode, graded-index fibers with optical and l properties consistent with the program objectives.

.1.2 Investigation of materials, processes, and techniques for ive coating and grouping of fibers. The grouping shall contain six fibers resulting from the investigation of 3.2.1.1. Other non- elements may be incorporated in the grouping for filling or form s. Consideration shall be given to the fact that individual fibers accessible at each end of the cable for termination into connectors cated in 3.2.

.1.3 Investigation of materials, processes, and techniques for g of fiber grouping resulting from the investigation of 3.2.1.2. The , consisting of protective interlayers over the fiber grouping if ary, tensile strain relief, and jacketing shall be of minimum size ight consistent with providing the necessary physical and environmental tion. Consideration must be given to the fact that individual optical will have to be accessible at each end of the cable for termination nnectors as indicated in 3.2. Consequently all cabling elements ctive layers, jacketing etc.) must be removable without adverse effect optical and mechanical properties of the fibers.

2.1.4 Investigation of materials, processes, and design details to realization of the inherent level of nuclear and electromagnetic ion hardness of which tactical communications systems are capable .2.3.2.7).

2. Cable Design Objectives: The details of the construction of mpleted optical fiber communication cable are undetermined at this Size, weight, materials, and design will be optimized with respect technical evaluation criteria delineated in Section 3.2.2 of these ical Guidelines. However, for the purpose of providing guidelines, I shows the tentative design and performance objectives for the cable.

The use of metallic strength members in the cable construction is undesirable. All fiber lengths used in the cable shall have been proof-tested to a minimum tensile strength of 50,000 psi.

3.2.3 Cable Evaluation: The following criteria shall be used as a guide for evaluating the performance and establishing the optimum characteristics and performance requirements of the optical fiber cable. The evaluation need not be limited to the tests specified herein unless otherwise specified.

3.2.3.1 Transmission:

3.2.3.1.1 Attenuation: The attenuation per kilometer of cable shall be as indicated in Table I when measured at selected wavelengths in the region from 6,000 Angstroms to 10,600 Angstroms. A minimum of three and a maximum of six points shall be selected. One point shall be 8,200 Angstroms. The remaining points shall be mutually selected by the contractor and the COR.

3.2.3.1.2 Data Transmission: A one (1) kilometer length of cable shall be capable of transmitting a pulse having the characteristics indicated in Table I.

3.2.3.1.3 Numerical Aperture: The numerical aperture shall be as indicated in Table I when measured on a one (1) kilometer length of cable.

3.2.3.2 Mechanical and Environmental Tests: These tests are to be conducted after the Transmission Tests of Par. 3.2.3.1, herein. After each of these tests (or test groups acceptable to the government), the cable is to be inspected for individual fiber breakage, cabling damage under 5 x magnification, and attenuation per Par. 3.2.3.1.1. The objective is no fiber breakage or other visible degradation of the cable. Unless otherwise stated, attenuation shall not exceed 5.0 dB/km after mechanical and environmental testing.

3.2.3.2.1 Tensile Load: The cable shall be subjected to the static tensile force indicated in Table I, applied axially, for a period of one (1) minute, after which the attenuation shall be measured. The static load shall then be reapplied and the optical output level shall be monitored for a period of 48 hours to determine the effects of continued tensile loading.

3.2.3.2.2 Mechanical Tests: Per Par. 4.5.4.1 of Specification MIL-C-13777 with the following exceptions:

a. A means shall be provided for monitoring of optical continuity of the fibers where electrical continuity of conductors is indicated in the test procedures.

b. All mandrel tests are to be conducted with a 5XOD mandrel.

c. Suitable alternatives to the test equipment shown in Figures 3, 4, and 5 of MIL-C-13777 [illegible] l be considered.

d. The number of Bend and Twist cycles above 2,000 which the cable is capable of withstanding shall be determined.

e. The magnitude (kg-m) and number of Impacts which the cable is capable of withstanding shall be determined. The objective is 200 impacts at 0.415 kg-m.

3.2.3.2.3 Vibration per Method 514.2, Procedure VIII of MIL-STD-810.

3.2.3.2.4 Temperature Shock per Method 503.1, Procedure II of MIL-STD-810.

3.2.3.2.5 Humidity per Method 507.1, Procedure II of MIL-STD-810.

3.2.3.2.6 Fungus per Method 508 of MIL-STD-810. The test shall not be considered valid unless the controls per paragraphs 3.1.3 and 3.1.4 of Method 508 show not less than profuse growth over 50% of the area after the 14th and 28th day of test. Inasmuch as this is a test of the materials and fabrication processes and certain cleansing agents are known to inhibit the growth of fungus, the cable specimen shall not be cleaned prior to test. After test, there shall be no visible growth of fungus on any surface except sparse and tuberal development of the fungus spore, and no more than two unrelated minute colonies.

3.2.3.2.7 Nuclear Survivability: Test and/or analysis of the cable design shall be made to determine the degree of hardness of the cable in the presence of nuclear radiation. Levels in the range of 10^3 to 10^5 roentgen (Cobalt 60) and 10^{12} to 10^{14} neutrons/cm^2 (1 MeV equivalent) are of particular interest and should be included in the investigation. For testing purposes, these doses shall be delivered to the cables within a time interval which is short compared to the time interval (10 seconds) during which the cable is permitted to be inoperable following the irradiation. Actual dose levels and durations of application shall be determined with approval of the government.

3.2.4 Connector/Cable Assembly Phase: The major effort in this phase will be directed toward the design, fabrication, and evaluation of cable connectors (plugs), bulkhead receptacles, and cable assemblies, consisting of the graded index cables from the cable phase terminated with the plugs developed under this phase.

3.2.4.1 Plug Design Objectives: The major effort will be directed toward achieving a connector design which will provide a rugged, waterproof, environment-resistant termination for optical fiber cable. The approach for achieving the optimum connector design shall include, but not be limited to, the following considerations:

3.2.4.1.1 Field Repair: The objective is a connector design which is capable of assembly to the cable by trained technicians in a depot or mobile repair van. The design shall not require the use of molding or potting techniques for accomplishing the assembly. ~~However, for comparison purposes, a connector design (or designs) which does use molding or potting techniques should be investigated~~. The investigation will provide the basis for a decision as to which design will be selected for the final models. Accordingly, such factors as comparative costs, complexity, reliability, ease of assembly, and performance consistent with the technical evaluation criteria of paragraph 3.3 herein must be considered.

3.2.4.1.2 Cable Preparation: Methods and techniques for preparation of the cable ends for proper assembly with the connector shall be established. This shall include details as to tools, processes, solvents, and stripping dimensions for removal of jacketing, encapsulants, and fiber coatings. Preparation of optical fiber ends to provide the most efficient optical surface shall also be addressed.

3.2.4.1.3 Cable Strain Relief: The connector design shall include a suitable cable strain relief. The optical fibers which are contained within the confines of the connector housing must be isolated from direct tensile and bending forces which are applied to the cable extending beyond the confines of the connector. Furthermore, the strain relief must also provide resistance to cable pullout or damage when subjected to the cable retention, flex-life, and twisting tests of paragraphs 3.2.5.2.7, 3.2.5.2.8, and 3.2.5.2.9 herein.

3.2.4.1.4 Mating Characteristics: The mating faces of the connector shall be optical with minimal crosstalk between adjacent optical paths and coupling loss between connectors. The optical mating faces must be suitably protected to prevent permanent degradation of light transfer between mating connectors as a result of repeated matings and unmatings, and exposure to moisture, water immersion, dirt, dust, sand, salt spray, and temperature extremes. The mating surfaces shall be easily accessible for cleaning with water, dry cloth, or small brush. The connector mating face and positive locking-coupling device shall be completely hermaphroditic to permit termination of both ends of the cable with identical connectors. The coupling device shall be free turning with respect to the connector shell.

3.2.4.2 Bulkhead Receptacle Design Objectives: The bulkhead receptacle shall include, but not be limited to, the following considerations:

3.2.4.2.1 Mating Characteristics: The mating characteristics shall be essentially the same as cited for the plugs in paragraph 3.2.4.1.4 herein. However, the device for coupling to plugs shall not be free turning with respect to the connector shell.

3.2.4.2.2 Mounting: The receptacle shall have bulkhead, D-hole type mounting with jam-nut threads and panel seal. Provision shall be made for accommodating panels up to .0064 meter thick.

~~3.2.4.2.3 Removable Optical Fibers: The connector shall contain provision for removal and insertion of individual buffered optical fibers at the rear of the connector. The individual removable fibers shall be held firmly in place after insertion and capable of being released for removal when required. This feature is required to provide coupling to light sources and detectors.~~

3.2.5 Connector Evaluation: The following criteria shall be used as guide for evaluating the performance and establishing the optimum characteristics and performance requirements of the connectors. The evaluation need not be limited to the tests specified herein. Unless other specified, the test specimen shall consist of a connector assembled to a cable. The length of cable shall be the minimum length required for valid measurement of the optical properties (paragraph 3.2.5.1) and to enable analysis of the effects of the mechanical and environment tests (paragraph 3.2.5.2) on the optical properties. The attenuation of individual fibers of the cables shall be no greater than 5 dB/km. Detailed test methods including the cable lengths and optical test measurements shall be provided to the COR for approval prior to the start of the technical evaluation.

3.2.5.1 Optical Tests:

3.2.5.1.1 Coupling Loss:

3.2.5.1.1.1 ~~Plugs~~ Connectors: The coupling loss of mated pairs of ~~plugs~~ connectors, each assembled to a length of cable, shall be determined on an individual optical channel to channel basis. The objective is 1.0 dB.

~~3.2.5.1.1.2 Bulkhead Receptacles: The coupling loss of a mated pair of connectors consisting of a plug assembled to a length of cable and a bulkhead receptacle with removable fibers inserted (as described in 3.2.4.2.3) shall be determined on an individual optical channel to channel basis. The objective is 1.5 dB.~~

3.2.5.1.2 Crosstalk: Near-end and far-end crosstalk in adjacent optical channels of a mated pair of connectors, prepared as specified in 3.2.5.1.1 herein, shall be determined. The objective is 100 dB down from the signal level inserted in the exciting channel.

3.2.5.2 Mechanical and Environmental Tests: These tests are to be conducted after completing the Optical Tests of paragraph 3.2.5.1 specified herein. Unless otherwise stated, after each of these tests (or test groups acceptable to the COR), the test specimen is to be inspected under 5X magnification for physical deterioration as indicated for each test, and the Optical Tests of paragraph 3.2.5.1. The objectives are no permanent degradation of the physical and optical properties of the test specimen.

3.2.5.2.1 Rotation: (Plugs) - The torque, measured with a torque wrench, required to rotate the coupling nut shall not exceed 0.864 kg-cm.

3.2.5.2.2 Mating Durability: Plug specimens shall be subjected to 1000 complete cycles of mating and unmating. One cycle shall consist of complete engagement and disengagement of connectors. Lubrication of coupling devices is not permitted. Optical continuity shall be monitored throughout the cycling. At the completion of the 1000 cycles, the connector mating surfaces may be cleaned as indicated in paragraph 3.2.4.1.4 herein. Compliance of the specimens with objectives of paragraphs 3.2.5.1 and 3.2.5.2.1 shall be determined.

3.2.5.2.3 Salt Spray: Unmated plug specimens shall be subjected to the Salt Spray Test of MIL-STD-202, Method 101, Condition B. The connectors shall show no evidence of corrosion, shall be capable of mating, and compliance with the objectives of paragraphs 3.2.5.1 and 3.2.5.2.1 herein shall be determined.

3.2.5.2.4 Immersion: Mated and unmated plug specimens shall be immersed in a tank of water to a depth sufficient to cover the cable entry end. Dry air shall be forced through the specimens at a pressure equivalent to a 1.83 meter head of water for 24 hours. Optical continuity shall be monitored on the mated specimens throughout the test. There shall be no evidence of air bubbles througout the test. Compliance of the mated specimens with the objectives of paragraph 3.2.5.1 shall be determined. The mating surfaces of the unmated specimens shall be dried thoroughly and then compliance with the objective of paragraph 3.2.5.1 herein shall be determined.

3.2.5.2.5 Shock Drop: Plug specimens shall be dropped at random six times mated from a height of 3.05 meters onto a .051 meter thick fir wood slab backed by concrete. The connectors shall be visually examined and the mated connectors tightened after each drop. The objectives are no loose parts, mating capability, no loss of optical continuity through mated pairs, and compliance with the objectives of paragraph 3.2.5.2.1 herein.

3.2.5.2.6 Sand and Dust: Plug and bulkhead receptacle specimens shall be subjected, unmated, to the Sand and Dust test of MIL-STD-202, Method 110, Test Condition B. There shall be no physical impairment of the specimens and compliance with the objectives of paragraphs 3.2.5.1 and 3.2.5.2.1 herein shall be determined.

3.2.5.2.7 Cable Retention: The plug specimens shall be subjected to a static tensile load of 181.44 kg for one minute applied to the cable at least .153 meters behind the back end of the plug. The load shall be applied in such a manner as to prevent cable damage in the vicinity of application of the load. The objective is no physical damage and compliance with the objectives of paragraph 3.2.5.1 herein shall be determined.

3.2.5.2.8 Flex Lif-: The plug specimens shall ? subjected to the nber of continuous f. x cycles specified below for room temperature and w : mperature. The connector shall be fastened securely and the cable ld .aut in the neutral axis. One complete flex cycle shall be ± 90° flex the cable about the neutral axis. Optical continuity shall be monitored rou hout the test. The objectives are no damage or loss of optical nti uity.

3.2.5.2.8.1 Room Temperature: The plug specimens shall be flexed for 30 ycles at a temperature of 23° ± 10°C. Flexing shall be in two anes, each mutually perpendicular to each other and to the face of the nnector. The line of intersection of the two planes shall pass through e c nter of the connector. Half the number of flexes shall be in one ane and half in the other plane.

2.5.2.8.2 Low Temperature: The plug specimens shall first be aged a circulating air oven for a minimum of 48 hours at 70° ± 2°C. The ecimens shall then be conditioned for a minimum of 48 hours at -55° ±2°C il attached to the flex life tester. Flexing shall then be conducted as ec..ied in 3.2.5.2.8.1 except that the total number of flex cycles shall 1000 (500 in each plane).

2.5.2.9 Twist: Mated plug specimens shall be tested, holding the nnectors stationary, and gripping the cable of one specimen .153 meters hi . its connector in such a manner as not to be damaging to the cable. e c ble shall then be subjected to 1000 twist cycles. One cycle shall nsist of a 180° twist (± 90° about the neutral axis). Optical continuity all be monitored throughout the cycling. The objectives are no physical ma : to the specimens nor loss of optical continuity as a result of the st.

2.6 Cable Assembly Evaluation: One kilometer long cable assemblies all be wound on reels and evaluated in accordance with the following iteria to establish the optimum characteristics and performance of the se lies. Two types of reels shall be used. One shall be Reel DR-5 and e other, a non-metallic reel, equivalent in size, which is capable of thstanding the evaluation tests. Provision shall be made on both reels r curing the connectors in place. Six sets of cable assemblies shall s jected to the evaluation tests. A set shall consist of two cable semblies, one wound on the DR-5 and the other wound on the non-metallic el. The sets shall be numbered 1 thru 6.

3.2.6.1 Assembly Throughout Loss: (Sets 1 thru 6) The assembly through-t loss shall be measured initially, in accordance with Figure I, on all be s, and shall not exceed 8 dB/km.

3.2.6.2 High Temperature (Set 1) - Per MIL-STD-810, Method 501.1, Pr dure II: The temperature for Step 7 shall be 85°C (185°F). The roughput loss shall be measured in Steps 7 and 10. Step 8 shall be itted. The objective is no increase from the initial value measured in 2.6.1.

3.2.6.3 Low Te' erature (Set 2) - Per MIL-ST 10, Method 502.1, Procedure I: The t...oughput loss shall be measured after the 24-hour stabilization period of Step 2 and in Step 7. Steps 3, 4 and 5 shall be omitted. The objective is no increase from the initial value measured in 3.2.6.1.

3.2.6.4 Temperature Shock (Set 3) - Per MIL-STD-810, Method 503.1: The throughput loss shall be measured in Step 7. The objective is no increase from the value measured in 3.2.6.1.

3.2.6.5 Humidity (Set 4) - Per MIL-STD-810, Method 507.1, Procedure II: The throughput loss shall be measured in Steps 4 and 9. The NOTE in Steps 4 and 8 shall not apply. The objective is no increase from the value measured in 3.2.6.1.

3.2.6.6 Vibration: Per MIL-STD-810, Method 514.2 (Cable Assemblies on reels. No receptacles.)

3.2.6.6.1 Secured Cargo (Set 5): Procedure X. After completion of the test cycle, the plugs shall be mated to the bulkhead receptacles and the throughput loss shall be measured. The objective is no increase from values measured in 3.2.6.1.

3.2.6.6.2 Loose Cargo (Set 6): Procedure XI. After completion of the test cycle, the plugs shall be mated to the bulkhead receptacles and the throughput loss shall be measured. The objective is no increase from values measured in 3.2.6.1.

TABLE [illegible]

CABLE OBJECTIVES

Physical:	
a. Length	1 kilometer
b. Number of fibers	6
c. Size overall (maximum)	.0064 meter
d. Weight (maximum)	28 kg/km
Transmission:	
a. Wavelength	6000 - 10,600 Angstroms
b. Attenuation (maximum)	5 dB/km
c. Data transmission	
(1) Bit rate	20 megabits/second
(2) Rise and fall times	4 nanoseconds
(3) Pulse flatness	3 dB peak to peak variation from voltage output level
(4) Pulse dispersion (maximum)	2 nanoseconds per kilometer
d. Numerical aperture	.14 minimum per kilometer length
Mechanical:	
a. Tensile load (6 meter gauge length)	181.44 kg
b. Vibration, Temperature, Humidity, Fungus	MIL-STD-810
c. Flexing, Impact, Twisting	MIL-C-13777
Nuclear survivability:	10^3 to 10^5 roentgens level (Cobalt 60) 10^{12} to 10^{14} neutrons/cm^2 (1 Mev equivalent)

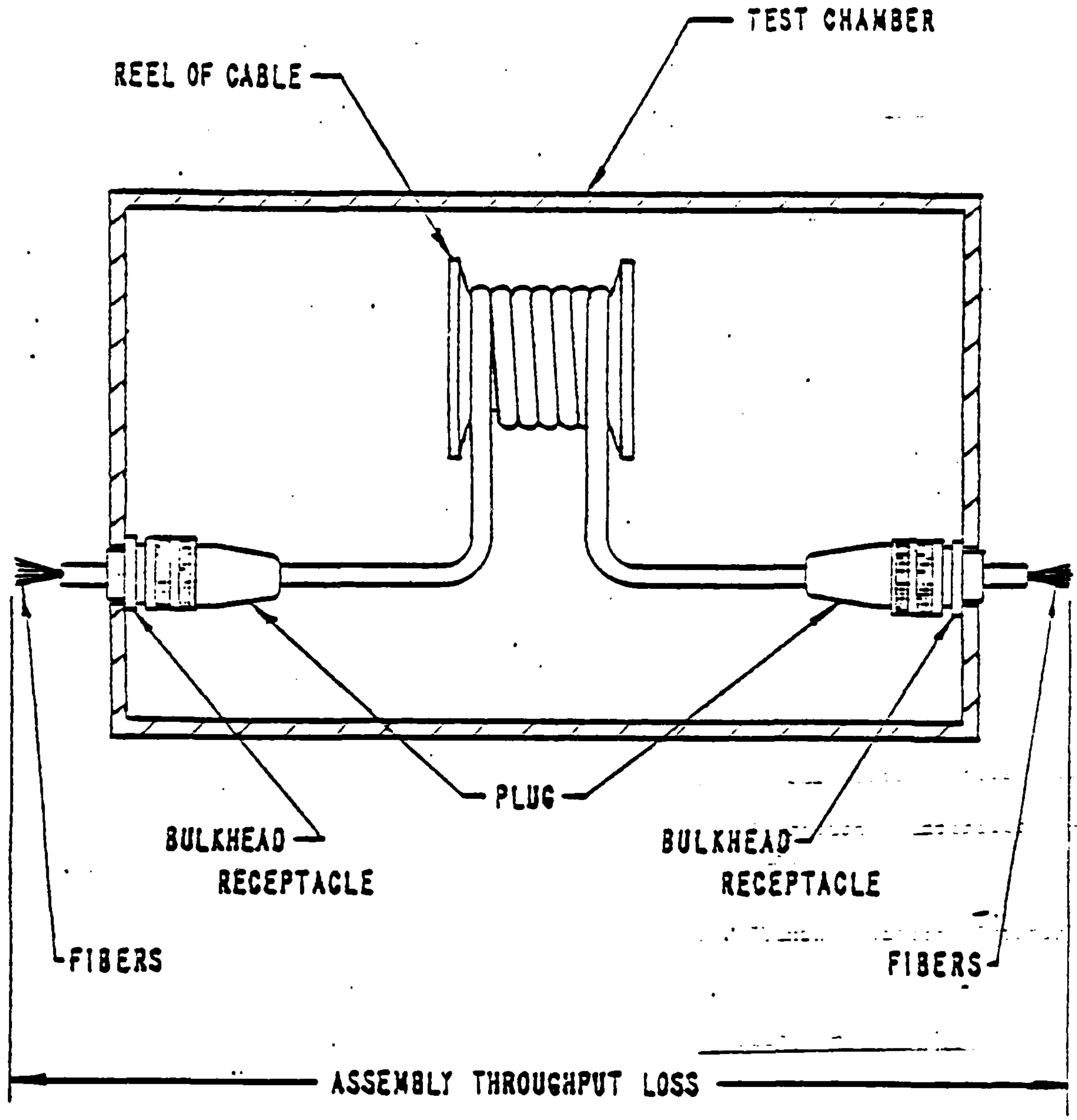

TEST CHAMBER
REEL OF CABLE
PLUG
BULKHEAD RECEPTACLE
BULKHEAD RECEPTACLE
FIBERS
FIBERS
ASSEMBLY THROUGHPUT LOSS

FIGURE 1

APPLICATION	
NEXT ASSY	USED ON
	TAOC

REVISIONS

LTR	DESCRIPTION		DATE	APPROVED
-	SCO # 10827 (Orig. Issue)	JDM	4/29/82	AH
A	SCO # 10945	JDM	6/11/82	AH
B	SCO # 10968	JDM	6/29/82	AH

PROCEDURE FOR TERMINATING

MULTIPLE OPTICAL FIBER CABLE WITH

THE HUGHES 6-CHANNEL

BULKHEAD RECEPTACLE CONNECTOR

SHEET SIZE																								
REV. LETTER																								
SHEET NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON

.XX DEC	.XXX DEC	ANGLE
±.02	±.005	±1/2°

MATERIAL

CONTRACT NO.

APPROVALS

DRAWN	
CHECKED	AH 5-11-82
ENGR	AH 5-11-82
ITT	
OTHER	

ITT ELECTRO-OPTICAL PRODUCTS DIVISION
7635 PLANTATION ROAD
ROANOKE, VIRGINIA 24019

PROCEDURE FOR TERMINATING
MULTIPLE ~~OPTICAL FIBER CABLE~~ WITH
THE HUGHES 6-CHANNEL
BULKHEAD RECEPTACLE CONNECTOR

SIZE	CODE IDENT NO.	DRAWING NO.
A	13567	RTVJ 213,751

SCALE	B	SHEET	1 of 37

ISD-004 3/73 004-066

C-14 AB02, BD, 25, 27, BB01, BB02, BB06, BR14, BR15 3A

40-240725

1.0 SCOPE:

1.1 This is a detailed assembly procedure for the termination of multifiber optical cable to the Hughes 6-channel bulkhead receptacle connector.

2.0 REFERENCE DOCUMENTS:

2.1 213,585 - Fiber Optic Cable Assembly

2.2 213,784 - Fiber Optic Connector Socket Contact

2.3 213,785 - Fiber Optic Connector Pin Contact

2.4 FC 213,826 - Flow Chart - Assembly of Hughes Bulkhead Connector Cable Assemblies

2.5 213,587 - 6-Channel Bulkhead Receptacle

3.0 EQUIPMENT:

3.1 Cable Preparation

3.1.1 VA 211,638 or equivalent - Scissors

3.1.2 6" Ruler with 0.1" graduations or equivalent

3.1.3 VA 211,596-X, Strippers

3.1.4 VA 211,586 or equivalent - Diamond Scriber

3.1.5 Felt Tip Marking Pen (Optional)

3.1.6 0-1", 0.0001" accuracy, Outside Micrometers

3.1.7 "O"-ring Installation Tool (Optional)

3.1.8 Adjustable Spanner Wrench (Face-type)

3.1.9 Adjustable Open End Wrench with $\leq$1" Capacity

3.1.10 X-Acto Knife andBlades (Optional)

3.1.11 Needle-point Tweezers

3.2 Contact Installation

3.2.1 Needle Point Tweezers

3.2.2 0-100 gram Scale with 0.1 gram increments

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3.2.3 Bell Jar Vacuum Chamber

3.2.4 Contact Epoxying Fixture with Heat Controller (Hughes #1143690S or equivalent)

3.2.5 VA 211,606-2, 10 cc Disposable Syringe with approximately 6" of VA 211,376 Tubing

3.2.6 Circular Fluorescent Lamp with approximately 3X magnification window

3.2.7 VA 211,586 or equivalent, Diamond Scriber

3.3 Hand Lapping

3.3.1 6-Channel Adjustable Fiber Optic Contact Polishing Tool (Hughes CDD #1143225-2S or equivalent)

3.3.2 Single-Channel Adjustable Fiber Optic Contact Polishing Tool (Hughes CDD #10939928 or equivalent)

3.3.3 VA 211,586 or equivalent, Diamond Scriber

3.3.4 Polishing Discs and Tray (Hughes CDD #1127559S or equivalent listed below)

3.3.4.1 3000-Grit, 6" Diameter Diamond Disc (Crystalite #116 or equivalent)

3.3.4.2 6" Diameter Phenolic Polishing Lap (Crystalite #136 or equivalent)

3.3.4.3 Stainless Steel Tray

3.3.5 80X (approximate) Stereo Microscope with Illuminator

3.3.6 Microscope Illuminator for backlighting fibers

3.3.7 Scrub Brush or Toothbrush

3.3.8 150X (approximate) End Face Inspection Microscope

3.4 Automated Lapping and Polishing

3.4.1 Strasbaugh Model 6Y-DC-2 Grinder/Polisher with two 16" diameter Kemet Copper Solid Lapping Plates

3.4.2 Two 2-Stage Hyprez Minimiser Spray Units

3.4.3 Two Magnetic Stirrers

3.5 Final Assembly

3.5.1 475 Watt Heat Gun, Master or equivalent

3.5.2 Contact Insertion Tool (Hughes CDD #1143042-2S)

3.5.3 Alignment Sleeve Insertion/Removal Tool (Hughes CDD #1143895S)

3.5.4 Contact Removal Tool (Hughes CDD #TMF16RT006)

3.5.5 3/32" Hex Key

3.5.6 5/64" Hex Key

3.5.7 Backshell Wrench

.0 MATERIALS:

4.1 Cable Preparation

4.1.1 Solvent (2-Propanol or Isopropyl Alcohol) in plastic squeeze bottle

4.1.2 1/2" or 3/4" Wide Masking Tape

4.1.3 Disposable Paper Wipers

4.1.4 Single Edge Razor Blades

4.1.5 Solvent (Acetone) in plastic squeeze bottle

4.1.6 Cotton Swabs

4.2 Contact Installation

4.2.1 1/2" or 3/4" Wide Masking Tape

4.2.2 Disposable Paper Wipers

4.2.3 Aluminum Weighing Pans

4.2.4 Flat Wooden Toothpicks

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4.2.5 Cotton Swabs

4.2.6 Solvent (2-Propanol or Isopropyl Alcohol) in plastic squeeze bottle

4.2.7 Solvent (Acetone) in plastic squeeze bottle

4.3 Hand Lapping and Polishing

4.3.1 VA 213,818-1, .3 Micron Alumina Disc, 6" diameter 3 mil Polyester back (if polishing method II is used)

4.3.2 Two 250 ml Beakers of Solvent (2-Propanol or Isopropyl Alcohol)

4.3.3 Water in plastic squeeze bottle

4.3.4 Solvent (2-propanol or isopropyl alcohol) in a plastic squeeze bottle

4.3.5 Four Baths of Clean Tap Water (2 for lapping; 2 for polishing)

4.3.6 Single-Edge Razor Blades

4.3.7 VA 214,782-1, 1 Micron Water Soluble Diamond Compound (if polishing method I is used)

4.3.8 Disposable Paper Wipers

4.3.9 VA 214,807, Water Soluble Lubricant (if polishing method I is used)

4.3.10 Atomizer/Sprayer (if polishing method I is used)

4.4 Automated Lapping and Polishing

4.4.1 VA 213,819-1, 1/2 Micron, Standard Concentration, S-841 Grade Diamond Slurry

4.4.2 VA 213,819-4, 9 Micron, Standard Concentration, S-841 Grade Diamond Slurry

4.4.3 VA 214,779, Aquasol #1 Cleaning Solution Concentrate

4.4.4 VA 214,807, Water Soluble Lubricant

4.5 Final Assembly

4.5.1 Solvent (2-Propanol or Isopropyl alcohol) in plastic squeeze bottle

4.5.2 Disposable Paper Wipers

4.5.3 Aerosol "Dust Remover"

5.0 PROCEDURE:

5.1 Coating of Marking

5.1.1 Using a paper wiper dampened with solvent (2-Propanol or Isopropyl alcohol), clean the marking area of the connector housing and the dust cover.

5.1.2 Using a cotton swab, coat the marking on the dust cover and connector housing with fungus/moisture resistant varnish.

5.1.3 Allow the varnish to air dry for at least 12 hours before handling.

5.1.4 Wrap the dust cover and the outside of the connector housing with foam packing material to protect the finish from damage due to handling.

5.2 Removal of the outer cable jacket

NOTE: Refer to the cable specification drawing for a cross-sectional view of the cable.

5.2.1 Using a paper wiper dampened with solvent (2-Propanol or Isopropyl alcohol), clean the last meter of cable at the end to be terminated.

5.2.2 Refer to the cable assembly drawing for the proper orientation of the cable markers. Slide the cable markers over the cable to a point where they will not interfere with the termination process.

NOTE: Do not adhere (or shrink) the cable markers to the cable at this time.

5.2.3 Slide the connector housing, notched end first, over the cable.

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5.2.4 Slide the piece of bend limiter shrink tubing and the inner sleeve, knurled end first, onto the cable.

5.2.5 Bend the cable around your fingers at least six inches from the cable end as shown in figure 5.2-1. Using an X-Acto knife or razor blade, carefully make a cut around the circumference of the cable outer jacket at the bend with single strokes. The cut should be deep enough to expose the yellow Kevlar strength members, but not damage them. Gently pull the outer jacket off and discard it.

5.2.6 Visually inspect the Kevlar strength member where the outer jacket was cut to ensure it has not been damaged. If the Kevlar has been damaged, check with engineering for next operation.

5.2.7 The strength member can now be taped back with masking tape along the cable outer jacket, reducing the possibility of it becoming damaged.

5.3 Removal of the cable inner jacket

NOTE: This process may be performed using either of two methods. The method described in steps 5.3.1 thru 5.3.2 is preferred by most individuals

<u>METHOD I</u>

5.3.1 Starting at the exposed end of the cable, insert a razor blade or the blade of an X-Acto knife under the inner jacket. With the sharp edge of the blade, carefully slit the inner jacket approximately 1" up the length of the cable.

CAUTION: Be careful not to nick the jacketed fibers.

Grasping the free jacket end just cut, pull the jacket back parallel to the cable axis and away from the cable end. Using masking tape, tape the jacket fibers to a tabletop so the cable to be stripped extends from the tabletop. Refer to figure 5.3-1. When done correctly, the jacket will fold back over itself for approximately 1/8". This folded over section is where the next cut is made to progress the slit up the cable. As the folded over section is cut, the inner jacket is permitted to be pulled back. Continue in this manner until the inner jacket is slit to within 1/8" of the outer jacket.

5.3.2 Using the razor blade or X-Acto knife, carefully make a circumferential cut around the cable inner jacket at the end of the slit. This cut should be deep enough to expose the jacketed fibers, but not damage them. Gently pull the inner jacket off and discard it. Proceed to step 5.3.4.

METHOD II

5.3.3 Bend the cable, at the point where the outer jacket ends, around your fingers.

Using an X-Acto knife or razor blade, carefully make a circumferential cut around the cable inner jacket within 1/8" of the outer jacket. The cut should be deep enough to expose the jacketed fibers but not damage them. Gently slide the inner jacket off in short strokes and discard it.

5.3.4 Visually inspect the jacketed fibers to ensure they have not been damaged during the inner jacket removal process. If a fiber jacket has been penetrated, cut off the prepared end and return to 5.1.

5.3.5 If a jacketed filler member (a strand of Kevlar with a plastic jacket) is present, cut it off within 1/4" of the cable inner jacket with an X-Acto knife, razor blade, or serrated blade scissors.

5.4 Strength member tie-off assembly

5.4.1 Place the locking sleeve, narrow end first, over the Kevlar strength members and the fibers and slide it down the cable until it butts against the outer cable jacket.

Hold the Kevlar strength members aside and slide the "o"-ring over the jacketed fibers.

5.4.2 Comb out the Kevlar, making sure the locking sleeve is butted against the outer cable jacket, slide the "o"-ring forward over the locking sleeve and Kevlar until it rests in the "o"-ring groove on the locking sleeve.

NOTE: At any time, the Kevlar can be wetted with solvent (2-Propanol or Isopropyl alcohol) to facilitate easier handling.

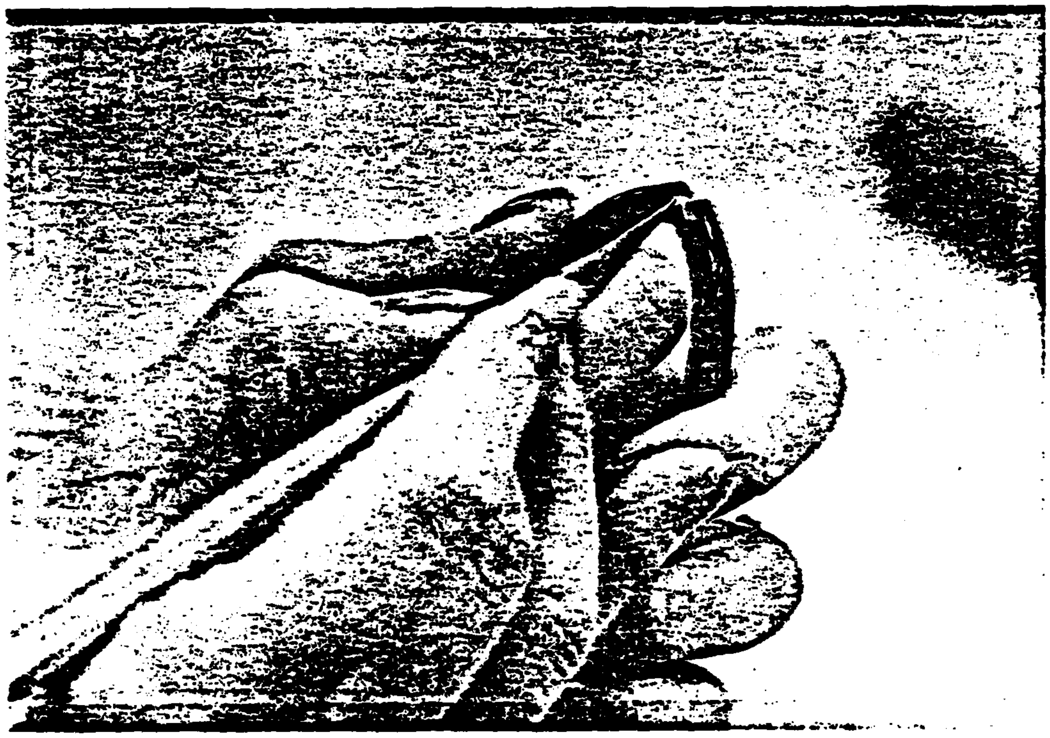

Figure 5.2-1. Cutting Outer Jacket.

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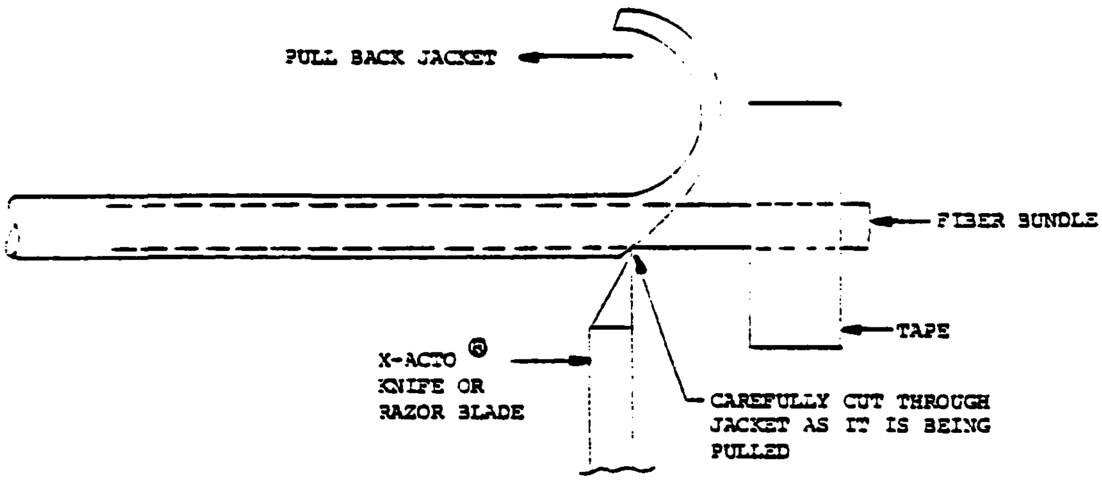

Figure 5.3-1. Removal of Inner Cable Jacket.

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5.4.3 Bring the Kevlar forward over the jacketed fibers, slide the jam nut, threaded end first, over the Kevlar® and jacketed fibers. Slide the inner sleeve forward, seating the locking sleeve into the inner sleeve. Engage the jam nut and tighten using the spanner and open end wrenches.

5.4.4 Using the serrated blade scissors, trim the excess Kevlar® flush with the face of the jam nut.

5.5 Fiber end preparation

5.5.1 Dampen a paper wiper with acetone and wipe it along the jacketed fibers until the color code ink is completely removed from the first 4 inches of the fiber jacket.

NOTE: This step is not required for fiber jackets fabricated with colored Hytrel.

5.5.2 Fiber end preparation - Method I

NOTE: This process may be performed using either of two techniques. The technique described in step 5.5.3 is preferred.

5.5.2.1 Using masking tape, secure the cable to a tabletop so the jacketed fibers extend about 2" over the edge of the table.

5.5.2.2 Using masking tape, secure the jacketed fibers to the tabletop. If multifiber cable is being used, orient the jacketed fibers so they fan out about 3/8" from one another.

5.5.2.3 While holding the end of the jacketed fiber under moderate tension with one hand, cut through the fiber jacket using a razor blade or X-Acto® knife held at approximately 30° to the fiber. Refer to figure 5.5-1 Slowly draw the razor blade or X-Acto® knife down to the end of the fiber. Repeat this same procedure on the opposite side of the fiber, removing the fiber jacket in its entirety. The stripped fiber dimensions should be as shown in figure 5.5-3. Proceed to step 5.6.

5.5.3 Fiber end preparation - Method II

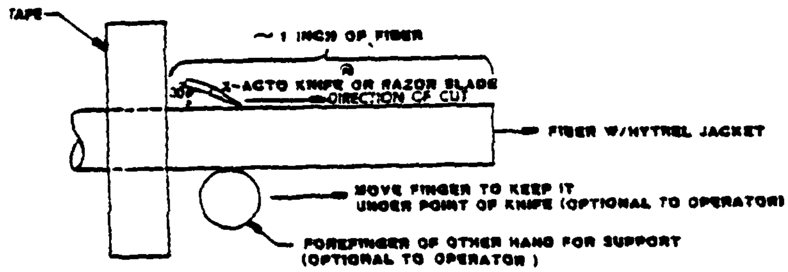
5.5.3.1 Using masking tape, secure the cable to a tabletop so the jacketed fibers extend about 2" over the edge of the table.

5.5.3.2 Using masking tape, secure the jacketed fibers to the tabletop. If multifiber cable is being used, orient the jacketed fibers so they fan out about 3/8" from one another.

5.5.3.3 Insert the jacketed fiber between the plastic centering guides of a Clauss No-Nik® strippers (use the 0.010" strippers for 0.5 mm fiber jackets; the 0.016" strippers for 1.0 mm fiber jackets). Position the strippers so only about 1/2" of jacketed fiber extends from the strippers.

NOTE: Right-handed operators should hold the strippers with the arrow Up; left-handed operators with the arrow DOWN.

Lightly squeeze the stripper handles; and using slow steady pressure, pull the strippers parallel to the fiber axis toward the fiber end. Repeat this process until the stripped fiber dimensions are as shown in figure 5.5-3. If the RTV buffer remains on the fiber, it can be removed with a razor blade using the technique described in 5.5.2.3. Proceed to step 5.6.



ONCE TOP PORTION OF HYTREL® IS REMOVED, REPEAT OPERATION WITH KNIFE AND FINGER ON OPPOSITE SIDE OF FIBER.

REMOVAL OF HYTREL® COATING

192 10775

Figure 5.5-1. Removal of Hytrel® Fiber Jacket.
(Method I)

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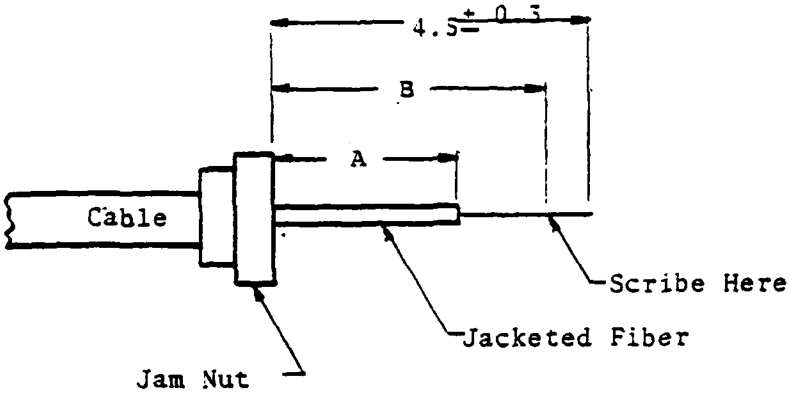

Connector Channel No.	Contact Type	Strip Dimensions (Inches)	
		A	B
1	Pin	3.0±0.1	3.7±0.1
2	Socket	3.3±0.1	4.0±0.1
3	Pin	3.0±0.1	3.7±0.1
4	Socket	3.3±0.1	4.0±0.1
5	Pin	3.0±0.1	3.7±0.1
6	Socket	3.3±0.1	4.0±0.1

NOTE: The Fiber color/connector channel cross-reference is given in the cable assembly drawing.

FIGURE 5.5-3

FIBER STRIPPING DIMENSIONS

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5.6 Fiber cleaning and cleaving

5.6.1 Dampen a paper wiper with solvent (isopropyl alcohol, or 2-propanol), and wipe it along the ~~bare~~ fiber until it is "squeaky" clean and all traces of RTV buffer are removed.

If the RTV buffer still remains on the fiber, dampen a paper wiper with solvent (acetone) and wipe it along the bare fiber until it is "squeaky" clean and all traces of RTV buffer are removed.

5.6.2 Place a piece of masking tape around the tip of your index finger, sticky side out. Gently squeeze about the last 1/4" of bare fiber between your thumb and the taped index finger. While applying moderate tension to the fiber, carefully and gently bring the diamond scribe close to the fiber about 1/2" from the unstripped jacket. In a single downward stroke, gently slide the point of the scribe across the diameter of the fiber. Slowly and steadily pull the fiber straight away from the table until it cleaves. Refer to figure 5.5-3 for an example of a prepped fiber.

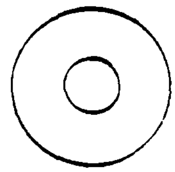
5.6.3 Using the micrometer, measure the diameter of the piece of bare fiber just cut off at two points 90° apart. Refer to figure 5.6-1. Record the cable serial number, fiber color, and the fiber diameter measurements. Retain the piece of fiber on the tape and record the fiber color on the tape.

5.6.4 Using a microscope with a magnification of 150X inspect the cleaved end of the fiber attached to the tape. The fiber core should be circular in appearance as illustrated in figure 5.5-4. If the fiber end is "NOT ACCEPTABLE", contact engineering immediatley. If the fiber end is "ACCEPTABLE" discard the piece of tape and fiber.

PREFERRED

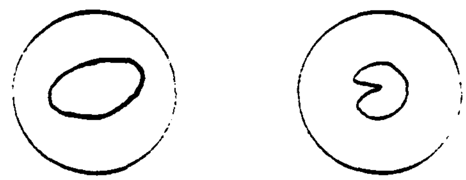
1. CIRCULAR CORE.

2. CORE CENTERED IN CLADDING.



NOT ACCEPTABLE

1. ELLIPTICAL OR IRREGULARLY-
   SHAPED CORE.



(VIEWED AT 150X MAGNIFICATION)

GO/NO-GO CRITERIA FOR FIBER CORES

FIGURE 5.5-4

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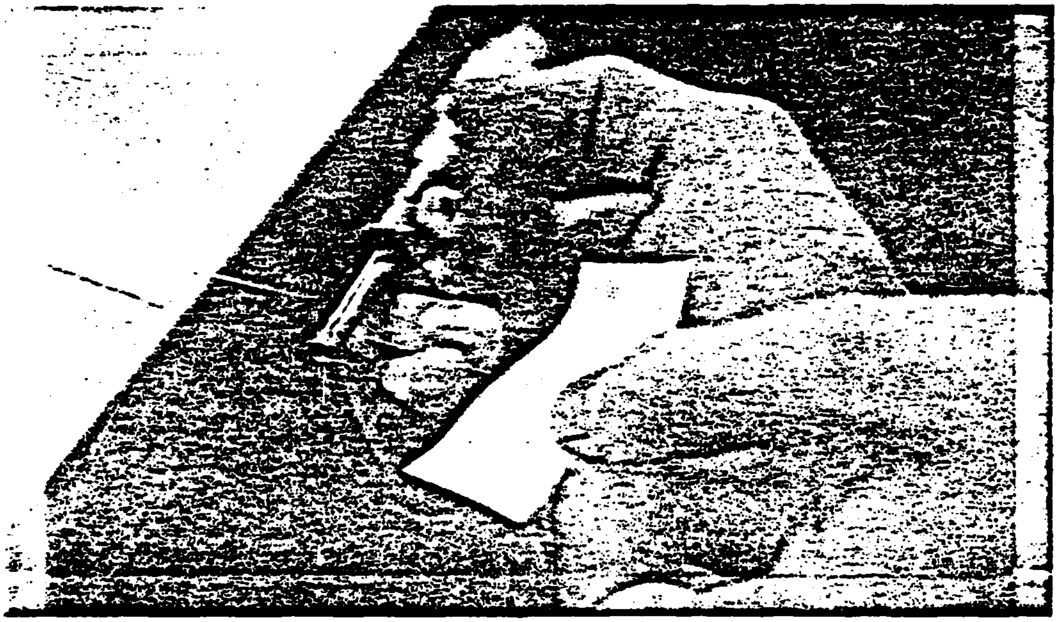

FGURE 5.6-1 Fiber Diameter Measurement.

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5.7 Contact selection and termination

5.7.1 Place the strength member tie-off into the notch in the curing station so its flat portion rests against the holder. Latch the toggle clamp down to secure the strength member tie-off in place.

5.7.2 Two different types of contacts, pin contacts and socket contacts, are used in the assembly of the Hughes connector. The socket contact, which is shipped with an alignment sleeve, looks the same as the pin contact except the socket contact does NOT have the belleville washers on its shank. The type of contact to be installed on each fiber is specified in figure 5.5-3.

5.7.3 To select the correct size contact, refer to fiber diameter measurements recorded in 5.6.3. If, for example, the fiber diameter was 0.0051", an 051 contact shall be used. If the fiber measured slightly less than 0.0051" but greater than 0.0050", then an 050 contact might be used instead of the 051 contact. The smallest contact hole should be used that can fit over the fiber.

5.7.4 Carefully slide the correct size and type of contact, eyeletted end first, over the fiber and gently rotate it until the fiber exits the precision drilled hole and the fiber jacket prevents further penetration. If the fiber will not fit through the precision drilled hole, select the next size larger contact and slide it over the fiber.

NOTE: Occasionally a slight burr in the eyelet at the rear of the contact ~~prevents~~ the fiber jacket from entering the contact. This burr can be removed prior to insertion of the fiber by gently reaming the eyelet hole slightly with the point end of a pair of needle nose tweezers.

5.7.5 Set the contact/fiber subassemblies into their respective grooves in the epoxy curing station so their weep holes face upward.

NOTE: All pin contacts fit the grooves marked "P"; all socket contacts fit the grooves marked "S".

Gently slide the holding clips over the contacts so they are held firmly in place.

CAUTION: The front edge of the holding clips should be located so the contact weep holes are not obstructed.

5.7.6 Carefully withdraw each fiber from its contact about 1/16" to 1/8" and tape the fiber jacket in this position on the holding block.

NOTE: Approximately 0.050" (1.25 mm) of bare fiber should be protruding from the precision drilled end of the contact.

5.7.7 Preheat the curing station to $55^{\circ} \pm 5^{\circ}C$ for at least five minutes.

Using a paper wiper dampened with solvent (isopropyl alcohol or 2-propanol), clean an aluminum weighing pan to remove any oily film and allow it to air dry.

Mix 10 parts, by WEIGHT, of Epo-Tek 330-D Part A resin and 1 part, by WEIGHT, of Epo-Tek 330-D Part B hardener in the cleaned weighing pan until the color is uniform.

The minimum batch size of epoxy to be made is 5.5 grams (total). Deair the epoxy by placing the pan in a bell jar vacuum chamber and pulling a vacuum until foaming is minimal. Release the vacuum. The epoxy is now ready for use and has a pot life of about one week. Label the pan of epoxy with your initials and the date the epoxy was mixed.

5.7.8 Using a piece of scrap fiber or a flat wooden toothpick, apply Epo-Tek 330-D epoxy at the eyeletted end of the contact to form a bead where the fiber jacket enters the contact. If the epoxy wicks into the contact, apply additional epoxy as required until a bead is formed.

CAUTION: Too large a bead will cause the contact to be bonded to the fixture.

Carefully slip the tubing of the vacuum syringe over the contact end with the syringe plunger fully inserted.

CAUTION: Use care so as not to break the end of the fiber.

Using a piece of scrap fiber or a flat wooden toothpick, apply Epo-Tek 330-D epoxy into the contact week hole until it is filled. To reduce the chance of entrapped air in the contact, always apply the epoxy at one side of the weep hole so air can escape on the other side. If an air bubble does appear in the weep hole, remove it with the end of a cotton swab. Apply moderate suction by slowly withdrawing the plunger from the syringe. This permits the epoxy to wick into and fill the contact. Continue to add drops of epoxy at the weep hole and eyeletted end of the contact until traces of epoxy can be seen entering the suction tubing or an epoxy bead is evident around the fiber where it exits the contact. An illuminated magnifier can be used to assist in viewing the formation of this epoxy bead.

CAUTION: Always maintain the suction on the epoxied contact until the suction tubing is removed; otherwise, air pockets will be introduced into the epoxy in the contact.

5.7.9 Slide the suction tubing off of the contact end, and remove any excess epoxy (refer to figure 5.7-1) from around the eyeletted end of the contact and the weep hole with the corner of a paper wiper, a clean wooden toothpick, or cotton swab.

NOTE: No epoxy is permitted in the belleville washers or spring clips, nor should excessive amounts of epoxy be evident at the eyeletted end of the contacts.

5.7.10 Apply a drop of epoxy over the precision drilled end of the contact to form a supportive bead around the fiber.

5.7.11 Set the temperature controller to 95° +5/-0°C and allow the epoxied contacts to cure for at least 45 minutes. When cured, the epoxy will change color from "straw" to orange/reddish-orange.

5.7.12 After the epoxy has completely cured, switch the temperature controller off, unclip the contacts, remove the tape securing the fiber jackets to the holding block, and release the strength member tie-off toggle clamp. Remove the contact/cable subassembly from the fixture.

NOTE: If the fixture is cool, a solvent (2-propanol or isopropyl alcohol) can be used to soften the tape's adhesive, facilitating its removal from the fiber jackets.

5.8 Preparation of the contact ends prior to grinding

5.8.1 Using the diamond scriber, scribe off any excess fibers as close to the epoxy bead as possible.

CAUTION: Do not snap the fiber off as this could induce cracks in the fiber core which cannot be polished out.

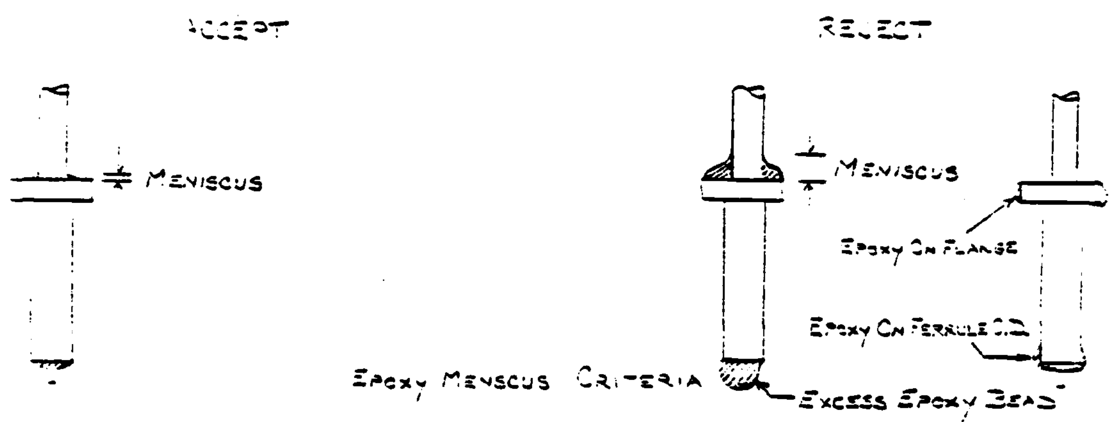

FIGURE5.7-1 Epoxy Meniscus Criteria.

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5.8.2 Using a single-edge razor blade, carefully peel off any excess epoxy which has cured on the outside diameter of the precision drilled contact end.

CAUTION: Do not gouge the contact surface or peel off the epoxy bead on the face of the contact.

5.9 Preparation of lapping and polishing plates

5.9.1 The lapping and polishing operations described later are carried out using abrasive substances (particles of significantly different size and character). The lapping operation takes place using a 3000 grit diamond wheel. These abrasive particles are very large in comparison to the polishing compound and if transferred to the polishing surface can easily cause the destruction of a finely polished surface. It is, therefore, important that the contacts and polishing fixture be washed free of grit from the lapping operation before beginning the polishing operation. A toothbrush or scrub brush can greatly speed the cleaning operation.

If several fibers are to be worked at any one time, it is best to perform all the lapping operations at one time and conduct a complete cleaning of the parts involved prior to beginning the polishing operation. This technique not only increases the overall speed of the operations but also decreases the likelihood of the contamination of the polishing surface.

5.9.2 Clean the surfaces of the lapping and polishing plates thoroughly using paper wipers and water. Allow the plates to air dry.

5.10 Lapping the contact end faces

NOTE: This process may be performed using either a single channel or multi-channel polishing fixture. For multifiber cables, it is preferred that the multichannel fixture be used. If the single channel fixture is used to polish multifiber cables, it is helpful to harness the contacts not being polished with masking tape. This harness should keep contacts already polished, or awaiting polishing, from being damaged.

5.10.1 Mount the contacts in the grooves on the polishing tool cradle. Slide the retaining sleeve over the nose of the cradle to hold the contact(s) in place. Secure the strength member tie-off with its holder to prevent fiber breakage (not required if the single-channel polishing fixture is used). Insert the cradle assembly into the adjustable carrier and engage the carrier lock-in pins by pushing the cradle into the tool and rotating it 30° clockwise.

5.10.2 Turn the selection knob so the "G" is facing upward toward the cradle top. This should make the face of the outer stainless steel ring (on the bottom of the tool) flush with the inner brass face of the tool.

5.10.3 Wet the surface of the 3000 grit diamond wheel with water. The diamond wheel must always be kept wet and all traces of lapped-off material washed off as required.

Place the tool face down on the diamond wheel and move it in a figure-8 pattern over the wheel. After a few revolutions on the wheel, unlatch the carrier key and slowly rotate the carrier clockwise as the tool is rotated over the diamond wheel Stop when the carrier key latches itself in the indexing notch.

5.10.4 Thoroughly rinse the polishing tool with clean water from a plastic squeeze bottle to remove all traces of grit from the grooves in the face of the tool. A wet scrub brush or toothbrush may be used to aid in the cleaning process.

5.10.5 Visually examine the fiber/contact end faces. The desired fiber end face appearance is a uniform, matte-like surface, free of deep scratches and pits, having no traces of epoxy on the face of the contact end.

5.11 Polishing the contact end face.

NOTE: The most important aspect of the polishing operation is cleanliness. A polishing surface contaminated with dirt or grit can completely ruin a fiber end face with one stroke of the polishing tool. Careful storage of the polishing surface and care to prevent the transfer of grit from the previous lapping step is generally sufficient to prevent contamination.

EXTREME CAUTION: Do NOT use any solvents to clean the phenolic lap. Solvents will dissolve the adhesive backing of the lap and corrode the aluminum disc.

Immediately dry the phenolic lap with paper wipers after use.

NOTE: This process may be performed using either of two techniques. The technique described in step 5.11.2 (Method II) is preferred.

5.11.1 Contact end face polishing - Method I

5.11.1.1 Apply four or five 1/4" diameter spots of 1 micron diamond paste onto the phenolic lap surface. Using the atomizer or a plastic squeeze bottle, apply a light film of lubricant solution (50% tap water plus 50% water soluble lube) over the lap surface. Using an empty polishing tool with the selection knob on "P", work over the entire lap surface for approximately one minute using light pressure.

CAUTION: If the polishing tool "drags" over the lap, spray additional lubricant solution onto the lap. The lap surface should now have a uniform "sudsy" film over it. If not, add additional diamond paste and lubricant as required until the "sudsy" surface is achieved.

5.11.1.2 Turn the selection knob on the loaded polishing tool so the "P" is facing upward toward the cradle top. This should cause the inner brass face of the tool to protrude beyond the outer stainless steel ring.

5.11.1.3 Carefully and gently place the loaded polishing tool onto the lubricated lap and revolve it in a circular pattern around the lap.

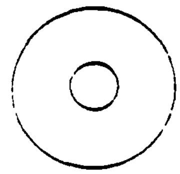
CAUTION: Always keep the lap surface covered with a uniform sudsy film - this is achieved by adding small additional amounts of lubricant and/or diamond compound. Do NOT over-wet the lap with lubricant to the point where the surface is flooded and mirror-like. Inspect the contact end frequently using a 150X microscope (rinse the loaded tool in water first). The desired fiber end face should be free of cracks within the core (when viewed both with and without fiber illumination) or surface scratches/pits in the core. Refer to figure 5.11-1.

NOTE: When trying to remove cracks or pits in the fiber with diamond lapping techniques, NEVER polish longer than 15 minutes. After this time, the end must be cut off and reterminated.

5.11.1.4 Once a good fiber end face is achieved, reverse the carrier one revolution to its original position. Then, push the cradle assembly forward and rotate it counterclockwise so it disengages from the carrier. Slide the retaining sleeve off of the cradle, and release the strength member tie-off from its holder.

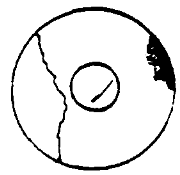
(@ 150X MAGNIFICATION)

PREFERRED



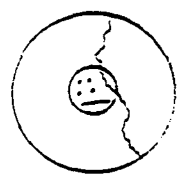
1. NO CRACKS, SCRATCHES OR PITS IN CORE.
2. NO CRACKS, SCRATCHES, PITS OR CHIPS IN CLADDING.

ACCEPTABLE



1. NO CRACKS OR PITS IN CORE.
   SURFACE SCRATCHES ON THE CORE WITH ROUNDED BOTTOMS + EDGES (RIPPLING).
2. CRACKS OR CHIPS WITHIN THE CLADDING BUT NOT EXTENDING TO THE FIBER CORE.
   NOTE: VERIFY BY BACKLIGHTING THE FIBER.

NOT ACCEPTABLE



1. CRACKS AND PITS IN THE CORE.
   DEEP SCRATCHES ACROSS THE SURFACE OF THE CORE.
2. CRACKS OR CHIPS WITHIN THE CLADDING EXTENDING INTO THE FIBER CORE.

INSPECTION CRITERIA FOR POLISHED CONNECTOR ENDFACES

FIG. 5.11-1

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SCALE	REVISION	SHEET
	5	21

5.11.1.5 Clean the polished contact(s) by agitating them in a bath of 1 part by volume Aquasol #1 concentrate and 8 parts by volume water. This will remove the diamond compound.

Rinse the polished contacts by agitating them in a bath of deionized water, and then in a bath of solvent (isopropyl alcohol or 2-propanol). Allow them to air dry.

5.11.1.6 The fiber end faces should again be visually inspected for cracks, scratches and pits (with and without fiber illumination) using a 150X microscope. Refer to figure 5.11-1.

5.11.1.7 Repolish and inspect any defective contacts per paragraph 5.11.

5.11.1.8 Thoroughly wash the polishing tool in two consecutive clean water baths or running tap water to remove all traces of grit and polishing compound from the grooves in the face of the tool. A wet scrub brush or toothbrush may be used to aid in the cleaning process.

Next, rinse the tool briefly in a solvent bath (isopropyl alcohol or 2-propanol) and allow it to air dry.

5.11.2 Contact end face polishing - Method II (Preferred)

5.11.2.1 Wet the surface of the phenolic lap thoroughly with water. Place one .3 micron alumina polyester backed polishing disc, shiny surface down, over the phenolic lap. Center the disc on the lap and work out any entrapped air bubbles between the disc and the lap.

5.11.2.2 Turn the selection knob on the loaded polishing tool so the "P" is facing upward toward the cradle top. This should cause the inner brass face of the tool to protrude beyond the outer stainless steel ring.

5.11.2.3 Thoroughly wet the polishing disc surface with water. Carefully and gently place the loaded polishing tool onto the wet polishing disc and revolve it in a circular pattern around the lap.

CAUTION: Always keep the surface of the polishing disc <u>wet</u> with water, occasionally wiping it clean with a paper wiper to remove any loose particles of epoxy, etc. Thoroughly flush the face of the polishing tool with water from a plastic squeeze bottle to remove any traces of grit from the contact end face and the tool. Visually examine the precision drilled metal end face of the contact for a highly polished surface. If the metal is highly polished, proceed to step 5.11.2.4. If not, continue the polishing operation.

5.11.2.4 Once a polished surface is achieved, reverse the carrier one revolution to its original position. The, push the cradle assembly forward and rotate it counterclockwise so it disengages from the carrier. Slide the retaining sleeve off of the cradle, and release the strength member tie-off from its holder.

5.11.2.5 Rinse the polished contacts by agitating them in a bath of water, and then in a bath of solvent (isopropyl alcohol or 2-propanol). Carefully dry them with a paper wiper.

5.11.2.6 The fiber end faces should again be visually inspected for cracks, scratches and pits (with and without fiber illumin-a tion) using a 150x microscope. Refer

5.11.2.6 (Cont.)

to figure 5.11-1.

5.11.2.7 Repolish and inspect any defective contacts per paragraph 5.11.

5.11.2.8 If the cable assembly will be stored for a few days prior to final assembly, the polished contact ends should be protected by lightly folding a piece of masking tape over the end of the contact.

5.12 Final assembly

5.12.1 Using a 3/32" Allen wrench, remove the cap from the transfer load bracket by removing the two screws. Install the strain relief assembly in the transfer load bracket so the flat of its jam nut rests against the bracket recess. Replace the cap and tighten the Allen screws.

NOTE: Ensure that the spacer washer is seated around the insert.

5.12.2 Using a 5/64" Allen wrench, loosen the set screw holding the transfer load bracket to the retaining shaft of the insert. Carefully slide the transfer load bracket off of the retaining shaft.

5.12.3 If the contact ends have been taped, flush the tape thoroughly with solvent (isopropyl alochol or 2-propanol) to soften the tape's adhesive.

Carefully remove the masking tape from the contacts. Rinse the contacts by agitating them in a bath of solvent (isopropyl alcohol or 2-propanol) to remove any residues from the tape. Carefully dry the contacts with a paper wiper.

5.12.4 Using the contact insertion tool, insert the contacts into their respective cavities in the insert (refer to the cable assembly drawing for fiber color/connector channel number correlation). Make sure the contacts are fully locked into their cavities.

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5.12.4 (Cont.)

NOTE: Properly installed contacts should have a small amount of axial play.

If the wrong contact has been inserted into a cavity, insert the tubular end of the contact removal tool into the front of the cavity over the end of the contact until a "snap" is felt and the tool cannot be inserted further. Depress the center plunger of the removal tool until the contact is pushed out the rear of the cavity. Remove the tool from the cavity.

5.12.5 Slide the insert assembly into the back of the bulkhead shell so the locating pin in the shell latches in keyway of the insert assembly.

5.12.6 Slide the connector housing over the insert assembly and tighten it into the connector shell.

CAUTION: Do NOT permit the fibers to bend in a radius less than 1" as fiber fractures may occur.

5.12.7 Once the connector has been assembled, blow the dust off the contacts by spraying them gently with "canned air."

CAUTION: Do NOT hold the nozzle of the canned air closer than 1/2" from the contacts. UNDER NO CIRCUMSTANCES SHOULD the container of canned air be used in an inverted position!

5.12.8 Install alignment sleeves onto the socket contacts as follows:

Place one alignment sleeve, split ring spacer end first, onto the "insert" end of the sleeve insertion tool. Press the alignment sleeve onto the socket contact as far as it will go, and remove the tool. If necessary, alignment sleeves can be removed by pressing the "REMOVE" end of the sleeve installation tool firmly into the alignment sleeve and then pull the tool away from the contact. The sleeve can now be removed from the tool.

5.12.9 Visually examine each installed alignment sleeve to ensure that its split ring spacer washer is present.

5.12.10 Remove the mounting jam nut from the connector shell. Place the dust cover tether washer over the shell threads so the tab angles toward the face of the connector and secure in place with the mounting jam nut.

5.12.11 Screw the dust cover over the end of the connector shell (if applicable).

5.12.12 Slide the piece of shrink tubing over the knurled portion of the inner sleeve as far as it will go.

5.12.13 Using the heat gun, shrink the tubing over the outer cable jacket and knurled portion of the inner sleeve.

CAUTION: Keep the heat gun at least 3" away from the cable jacket so the cable is not damaged by excessive heat.

5.13 Post-Test Assembly

NOTE: The following operations are to be performed on the cable assembly AFTER it has been optically tested and approved.

5.13.1 Slide the cable markers (if any) into position as shown in the cable assembly drawing. The lettering on the markers should line up within 45° rotation.

5.13.2 Using the heat gun, shrink the cable markers over the outer cable jacket.

CAUTION: Keep the heat gun at least 3" away from the cable jacket so the cable is not damaged by excessive heat.

5.13.3 Using a razor blade, cut the cable assembly at or near its midpoint - this will yield two pigtailed bulkhead receptacles.

6.0 ACCEPT/REJECT CRITERIA:

6.1 Optical loss testing will be performed as described in the cable assembly drawing. The optical loss for each channel will meet the limits specified or DMR will be initiated.

6.2 Rejected material may be reworked as required if sufficient cable length is available.

7.0 DELIVERY OR STORAGE:

7.1 Coil the connectorized cable and its work order/flow tag in a polyethylene bag or cardboard box and store until the next operation or shipment.

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SCALE	REVISION B	SHEET 33

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